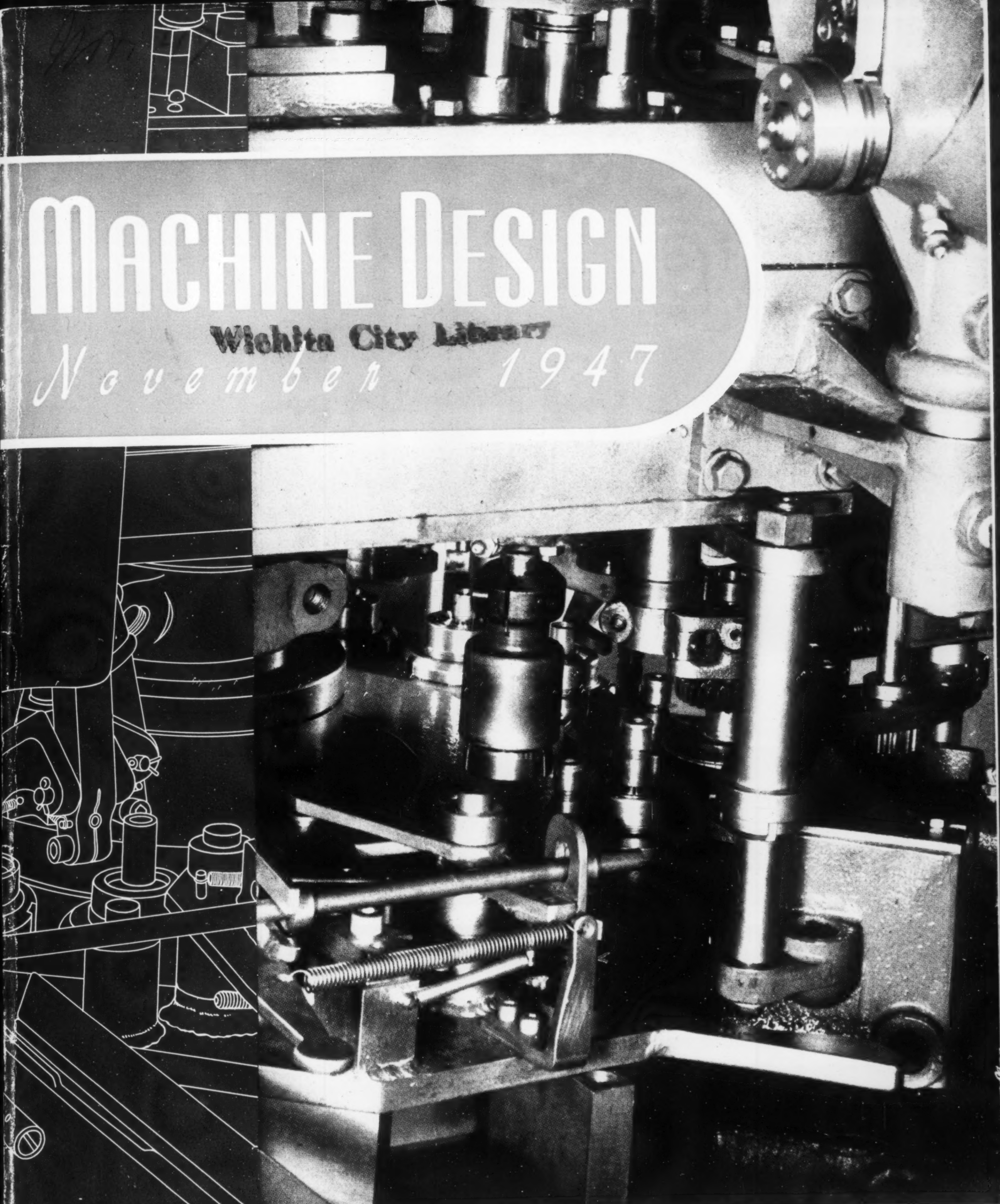
MACHINE DESIGN

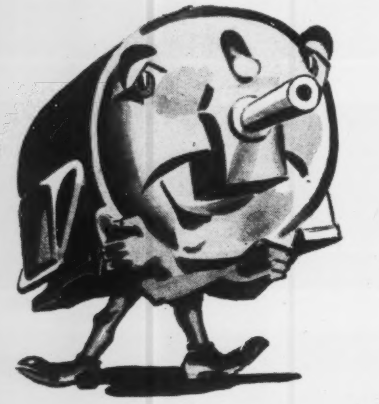
Wichita City Library

November 1947



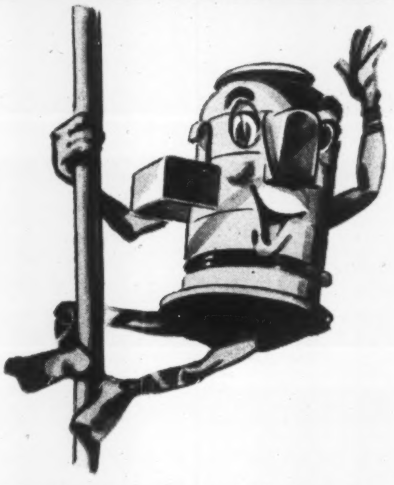
In This Issue: ESTIMATING COST OF NEW MACHINE
TORQUE LIMITING CLUTCHES . . . SPECIFYING SPRINGS

"Which Squirrel-Cage Motor Shall I Buy?"



Open-Type? This general-purpose squirrel-cage motor meets about 9 out of every 10 application requirements; so chances are it's the design you'll select. Allis-Chalmers builds generously proportioned, rugged *open-type* squirrel-cage motors in sizes from 1 hp to the largest practical requirement.

Splash-Proof? Where operating conditions are conducive to entrance of particles or liquids into ordinary motors from either top or sides, Allis-Chalmers *splash-proof* squirrel-cage motors may be your best buy. They're designed to *exclude* top or side directed particles and liquids. Sizes 1 hp to the largest.



Vertical? or Flange-Type? *Either* can solve a space problem. *Vertical* motors (sizes 1 hp to largest) for vertical drives. *Flange-mounted* for side or angle drives. In both types bearings and closures are designed to prevent grease escapement. Mounting flange for attaching to your base can be provided.

Totally-Enclosed? Explosion-Proof? Completely weather-proof and fan-cooled, these motors are built to beat abrasive dust, dirt and corrosive fumes, or moisture conditions that cause windings in ordinary motors to deteriorate. *Explosion-proof type* for oil refineries, paint, varnish or lacquer plants, etc.; Underwriters approved; reduce hazards in explosive or dust atmospheres. Either type built from 1 hp and up.

Are Motor Decisions More Important Today?

YOU BET THEY ARE! One *obvious* reason is the need for keeping costs down. Another is that in the rush to fill demand much equipment is being misapplied; making it harder to maintain profits not alone today, but tomorrow, the next day and the next year—as long as misapplication continues!

That's why it's important to take a good look at motors — their characteristics — your equipment — power source and surroundings — *before* you buy and apply! If you're in doubt, don't take chances — call a motor expert! ALLIS-CHALMERS, MILWAUKEE 1, WIS. A 2327

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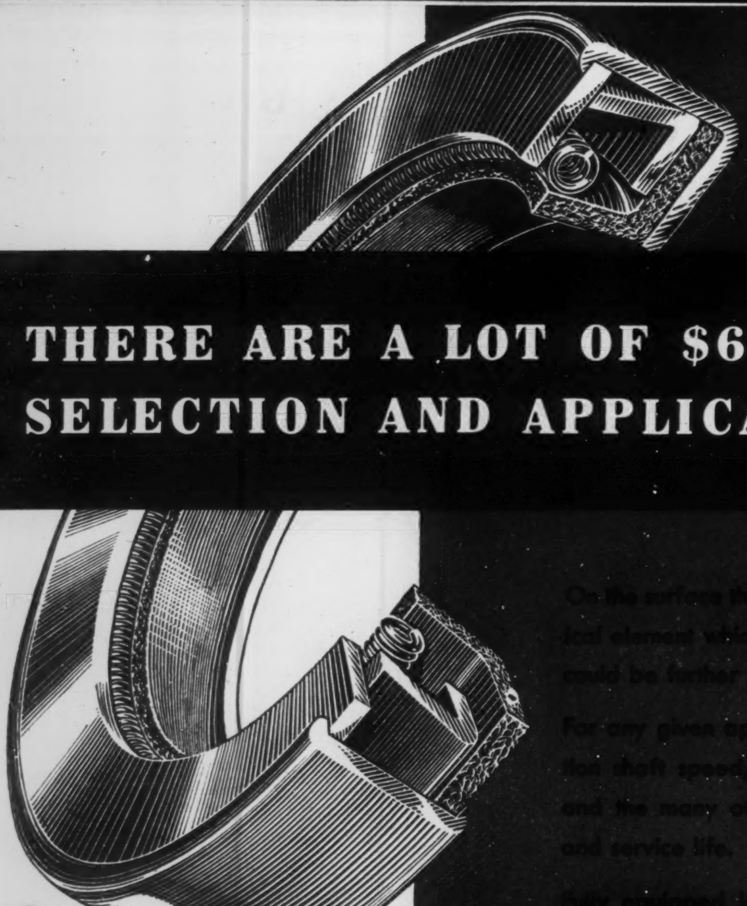

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Published on the seventh of each month.

MACHINE DESIGN
November 1947

This Month's Cover: Loading and unloading stations in automatic primer-tube assembler designed by Consolidated Packaging Machinery Corp. Mechanical detectors check each assembly for height, level of fill and omission of cap. Conveyor for removing loaded parts is shown in lower left.

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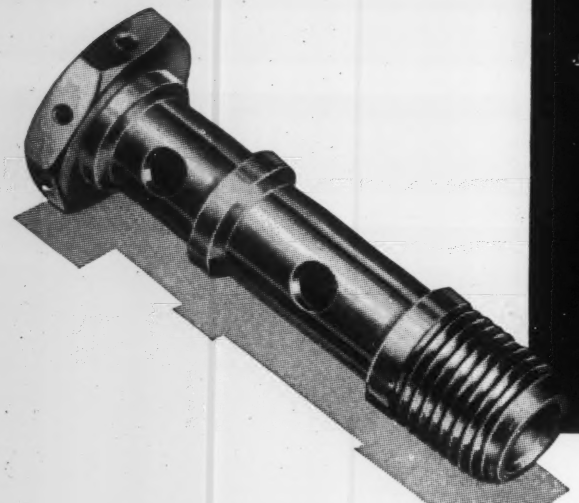

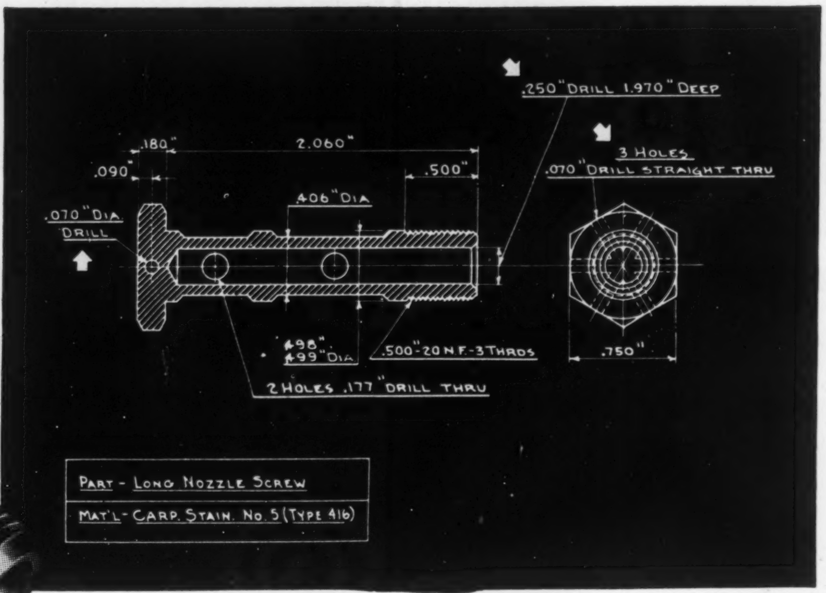

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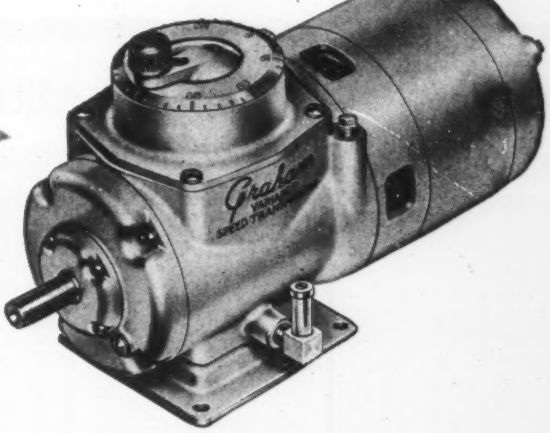

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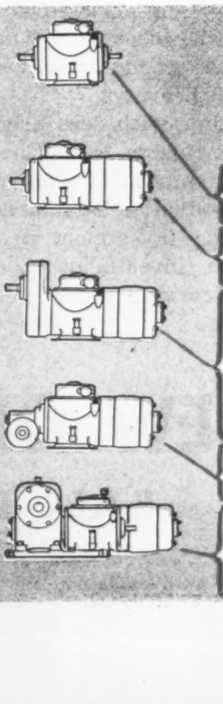
•

With built-in motor and built-in worm reduction, Model 40. Output shaft extends both sides horizontally or vertically up or down. Additional ratios available — 9:1, 12:1, 18:1, 36:1 and 47:1.



Model	Input Speed	Output Speed Range	In Lbs. Torque Rating		Approx. Ins. Overall Dimensions			Motor H.P.
			At Max. Speed	At Min. Speed	Lgth. incl. shaft ext.	Width	Height	
15	3600	1100/0	3.5	7.5	8¼	4⅝	5⅝	1/15 to ⅛
40	3600	1100/0	30	60	14½	7	8	¼ to ¾
15M	3600	1100/0	3.5	7.5	11½	4⅝	5⅝	1/15 to ⅛
40M	3600	1100/0	30	60	19½	7	8	¼ to ¾
15MR5	3600	220/0	15	35	13	4⅝	6¾	1/15 to ⅛
40MR5	3600	220/0	140	280	22	7	10	¼ to ¾
40MR2.8	3600	400/0	80	160	22	7	10	¼ to ¾
15MS2.5	3600	2750/0	1.3	2.8	13	4⅝	6¾	1/15 to ⅛
40MS2.8	3600	3100/0	10	20	22	7	10	¼ to ¾
15MW20	3600	55/0	35	75	12¾	4⅝	5⅝	1/15 to ⅛
15MW40	3600	28/0	60	120	12¾	4⅝	5⅝	1/15 to ⅛
40MW6	3600	190/0	120	250	24	8½	10½	¼ to ¾
40MW24	3600	46/0	420	840	24	8½	10½	¼ to ¾
40MW60	3600	19/0	800	1700	24	8½	10½	¼ to ¾

Everybody agrees
COSTS MUST
COME DOWN

One important place to start reducing costs is with the machine where goods are made.

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Operating with less friction, less wear than other types, the ball bearing is a "natural" for the higher speeds, greater rigidity and improved quality of product demanded by today's exacting production standards.

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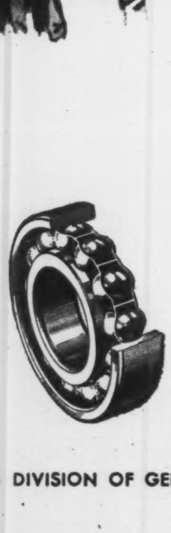
New Departure's technical literature is most helpful. Tell us your needs.



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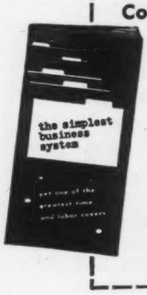

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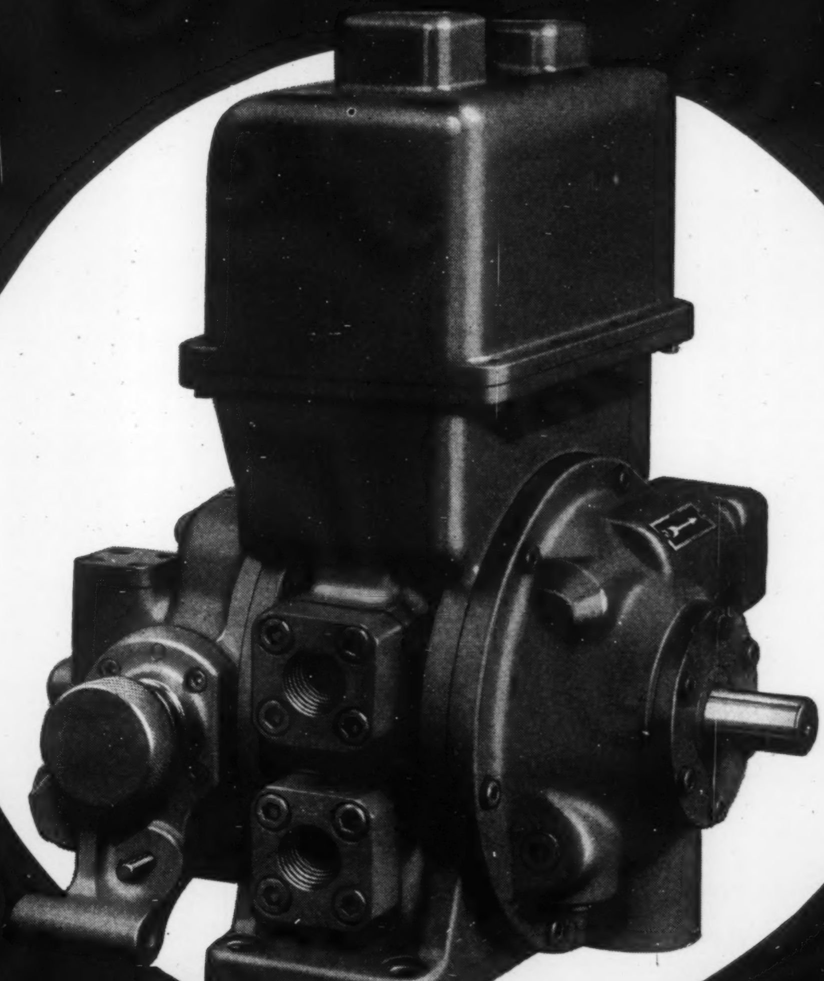

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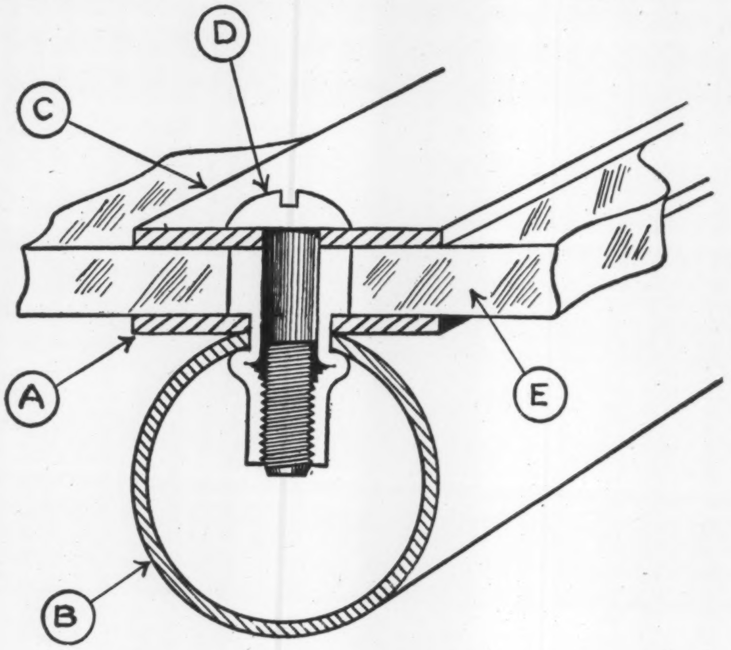
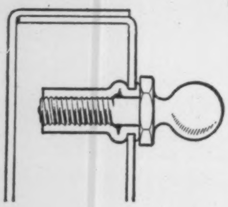
To provide a neat, tight seal for airplane windows, designers needed a simple, one-piece fastener—a blind rivet and nut plate combined. They found the ideal answer in a spacer-head B. F. Goodrich Rivnut.

With the easy-to-use heading tool, one man quickly upset the Rivnut, securely riveted plate "A" to tubular center post "B". The firm bulge formed in the Rivnut shank conformed to the curvature of the tube. The Rivnut head served as a spacer for transparent plastic sheets "E". Screw "D" was then threaded into the clean, still-intact Rivnut threads to hold clamp strip "C" and plastic sheets in place.

Besides providing a tight, dependable seal, Rivnuts saved many man-hours on this job. If you're looking for a fastener which can improve your product and cut production time, why not get the facts from a Rivnut engineer? Write The B. F. Goodrich Company, Dept. MD-117, Akron, Ohio.

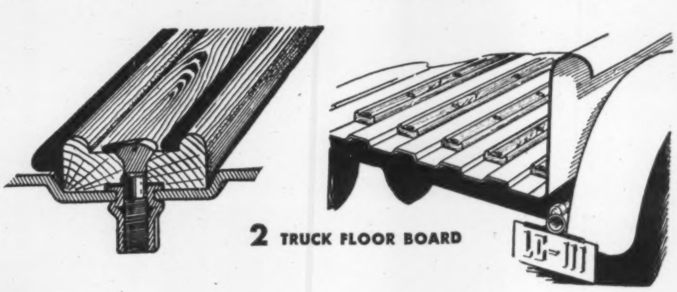


Other tough fastening problems solved by B. F. Goodrich Rivnuts



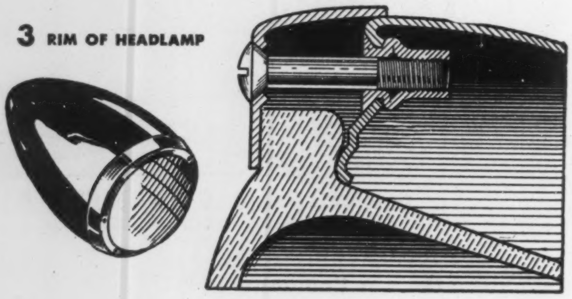
1 KITCHEN CABINET DOOR

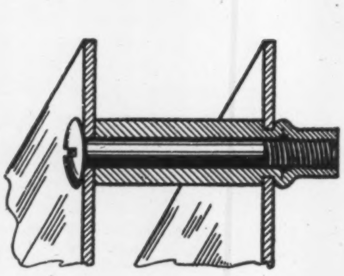
Rivnut used as a nut plate in sheet metal door of kitchen cabinet. Rivnut is installed from one side only, *after* door enameling. Threads are still clean after upsetting.



2 TRUCK FLOOR BOARD

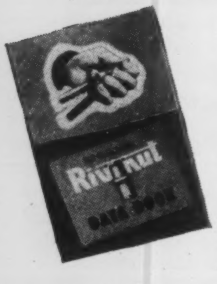
3 RIM OF HEADLAMP





4 STOVE WALLS

½" spacer head of Rivnut provides free air circulation through walls of gas stove. Easy-to-operate Rivnut heading tool made job faster, simpler.



QUICK, EASY INSTALLATION SHOWN IN RIVNUT DATA BOOK

Step-by-step installation is described in this fully-illustrated, 40-page latest edition. Rivnut types, sizes, applications given. 10 pages of test data. For your free copy write The B. F. Goodrich Company, Dept. MD-117, Akron, Ohio.

B.F. Goodrich

RIVNUTS

It's a rivet—It's a nutplate

This is a picture of a Link-Belt inspector engaged in assuring the efficient performance of Link-Belt Bearings. This, indeed, is ruthless, uncompromising inspection which greatly magnifies the image of the raceway and compares its profile with the master curve gauge. In the battle against friction, Link-Belt bearing designers and producers ask no quarter, nor do they give one. Link-Belt invites you to put your bearing problems in their hands.

The Link-Belt medium series single row self-aligning ball bearing illustrated here has the following features:

1 Spherical seat compensates for misalignment up to 2½ degrees, or ½" per lineal foot of shaft.

2 Spherical surfaces fully lubricated and protected from dust and dirt, assuring free aligning action throughout life of bearing.

3 Self-aligning grease seals of accurately formed pressed steel and long fiber felt.

4 Outside rotating member develops full flinger action.

5 Unit completely sealed at factory for permanent protection of bearing parts.

6 Knurled cup points firmly lock set screws in place.

7 True flat surface assured for nut pressure surface.

8 Compact, solid housing requires minimum support space. Base spotted for drilling for dowel pins. Elongated bolt holes facilitate alignment and assembly.

9 Ample grease reservoir.

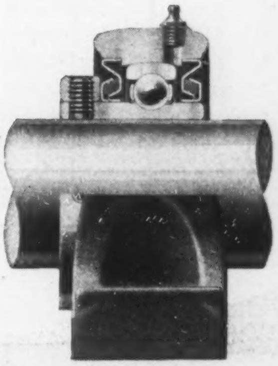
10 Extended inner race distributes bearing load over large shaft area.

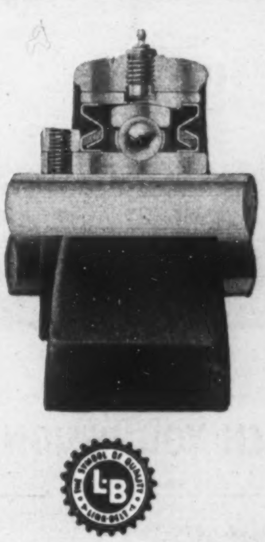
11 Double setscrewed collar locks inner ring assembly to shaft.

12 Hydraulic grease fitting conveniently located at 45° from horizontal center-line of bearing.

13 Locking plug equipped with hydraulic type grease lubrication fitting, conveniently located outside and allows axial movement of the cartridge.

14 Steel inner housing, completely assembled with bearing and seals, is free to float in bore of outer housing. Cartridge treated to prevent rust, assuring free axial movement, eliminating heavy thrust loads.





LINK-BELT ◄

BALL and ROLLER BEARINGS

LINK-BELT COMPANY: Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Dallas 1, Houston 2, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8. Offices, Factory Branch Stores and Distributors in Principal Cities. 10,285

MAKE IT MOVE with alliance MOTORS

Alliance Motors operate automatic controls, valves, switches, fans and blowers, air circulators, motion displays, phonograph turntables, record changers, air conditioning units, room heaters, automobile heaters, electric fans, magnetic disc tape and wire recorders, toys, business machines and numerous other devices.

Horse power ratings range all the way from 1/400th up to 1/30th h.p. Alliance Motors are light-weight, compact, and are mass-produced at low cost—made in both shaded pole induction and split-phase resistor type. Designed for particular jobs, some are uni-directional, others are reversible. Alliance makes motors for both continuous and intermittent duty. Wherever designs call for *more motion*—automatic action—remember, there is an Alliance Motor for the job!

Model K shaded pole induction type will develop up to 1/100th h.p.

Model A fan motor, 6 pole shaded design. Approximately 1/30th h.p.

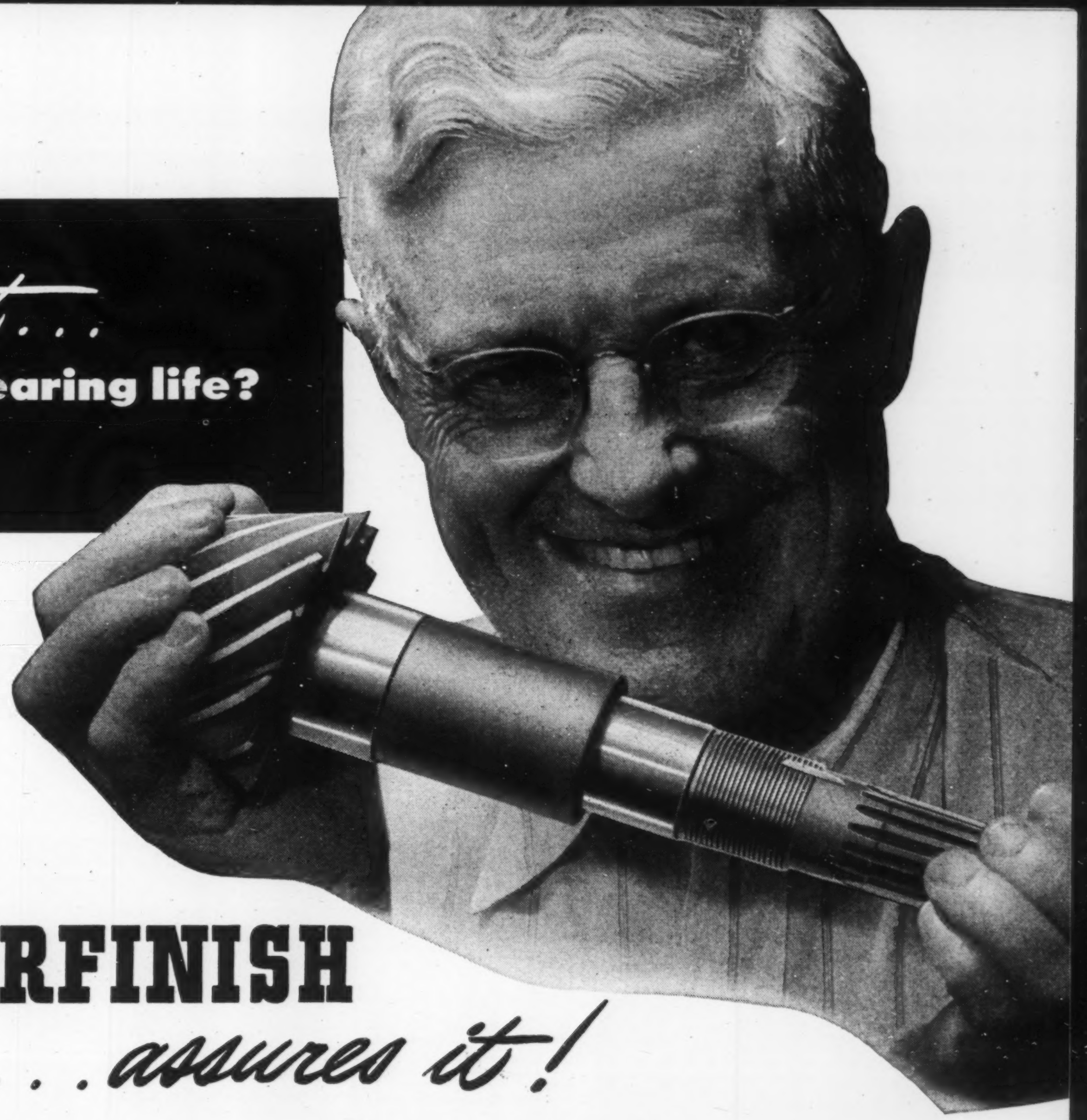
Model RR—fully enclosed, split-phase resistor type with or without gears.

Model MS shaded pole induction type motor, full load h.p. .0021

WHEN YOU DESIGN—KEEP alliance MOTORS IN MIND

ALLIANCE MANUFACTURING COMPANY • ALLIANCE, OHIO
Export Department: 401 Broadway, New York 13, N. Y., U. S. A.

want... longer bearing life?



SUPERFINISH

...assures it!

● Yes, you can double—triple—quadruple—the life of bearings with simple, precautionary measures which take only a few minutes.

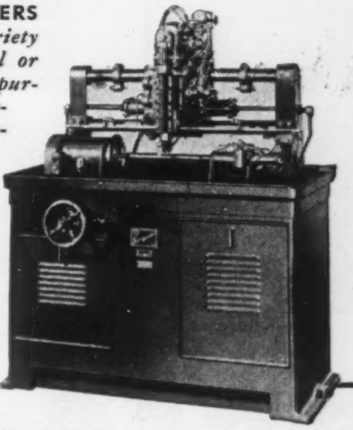
Examine a finely ground surface. No matter how smooth it may appear, it has defects in the form of grinder scratches, chatter and feed marks, and "smear metal" softened by the heat of grinding wheels. When these tiny metal ridges rub together, they rupture the protective oil film to cause scoring, excessive wear and increased clearances.

Superfinishing removes these defects—produces a bearing surface that is virtually frictionless. And its life is almost unlimited.

Superfinishing is a much quicker and more economical process than you may think. And it pays for itself many times over in better service and lower replacement cost.

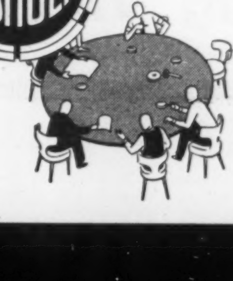
Ask your nearest Gisholt Representative for the facts about Superfinishing.

GISHOLT SUPERFINISHERS *are available in a variety of types for cylindrical or flat surfaces; for general purpose or continuous production work; also as attachments for use on lathes. Write for literature.*



GISHOLT MACHINE COMPANY · *Madison 3, Wisconsin*

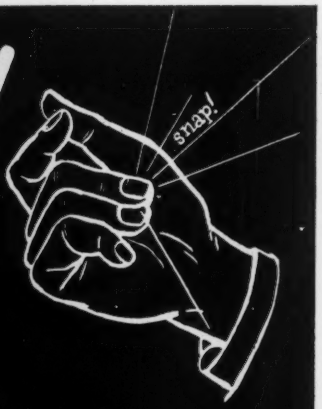
TURRET LATHES · AUTOMATIC LATHES · BALANCERS
SUPERFINISHERS GISHOLT SPECIAL MACHINES



THE GISHOLT ROUND TABLE

represents the collective experience of specialists in the machining, surface finishing and balancing of round or partly round parts. Your problems are welcomed here.

SNAP *and* STAMINA!



NEVER BEFORE in this type of valve—ruggedness, reliability, low cost and low maintenance, PLUS the choice of foot or hand lever control. That's Ross' answer for small air cylinder use on machines where easy operation, continuous high production and compactness are "musts". It's Ross quality, of course, precision-machined brass and stainless steel construction, yet at a price you can't afford to pass up.

Available
¼" 3-way
¼" 4-way
Your choice foot
or hand lever.

ROSS Operating VALVE CO.
6485 EPWORTH BLVD. • DETROIT 10, MICHIGAN

VENDORLATOR MAKES "The Pause That Refreshes" More Efficient with LORD FLEXIBLE COUPLINGS

In Vendorlator Vending Machines

DRINK
Coca-Cola

6 GOOD REASONS WHY VENDORLATOR SPECIFIES LORD FLEXIBLE COUPLINGS

1. *In the Thousands of Vendorlators Built, Have Never Replaced a Lord Coupling*
2. *Unusual Accommodation for Misalignment Reduces Bearing Wear*
3. *Quiet—Stop Noise Transmission*
4. *Isolate Motor Vibration*
5. *Unusual Torsional Flexibility Absorbs Starting Torque*
6. *Efficiency at Low Temperatures*

These are good reasons, too, for specifying Lord Flexible Couplings in *your product.* Like Vendorlator, you get unusual flexibility that cushions starting torque and torsional vibration . . . quiet performance—without noise transmission . . . long life—no lubrication required . . . all plus-values for your customers in smooth power transmission and trouble-free service.

Whether you make vending machines or something else, you'll want the longer life, the smooth, quiet performance, *and the increased sales* which Lord Flexible Couplings and Mountings can bring to your product . . . through elimination of costly, destructive vibration and noise.

It will pay you to consult Lord . . . let us give you the advantages of a Lord Vibration Control System engineered to your requirements. Write or phone us today.

The Vendorlator Manufacturing Company of Fresno, California uses Lord Flexible Couplings for power transmission between a 1/20 H.P. motor and the gear box of their beverage vending machines. Operating in the refrigerated compartment at low temperatures, these couplings, nevertheless, give excellent performance because of their unusual flexibility and accommodation for misalignment. As a result, motor overload and burnt out bearings, due to misalignment, are prevented. Although made of natural rubber for this application Lord Flexible Couplings are available in neoprene and in seven sizes up to 1 H.P. to suit your requirements. Send for Bulletin 200C for further information.

LORD MFG. CO
ERIE, PA.

ANOTHER EXAMPLE OF PRODUCT IMPROVEMENT
by
LORD
VIBRATION CONTROL SYSTEMS

MAKE GOOD PRODUCTS BETTER with *Vibration Control*

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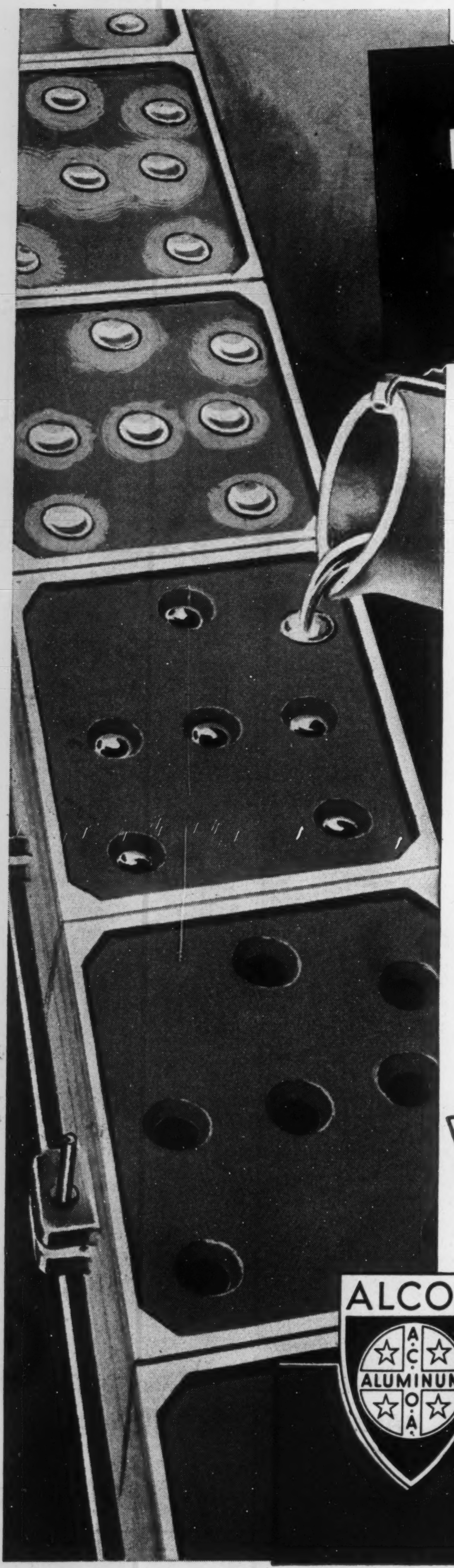

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Alcoa Castings Engineering Service . . . A.C.E.S. . . . has a background of almost 60 years of experience and data on aluminum castings. Has access to the research and development work done by Aluminum Research Laboratories. Makes use of the most advanced and complete scientific testing equipment to be found in any foundry. Draws on the knowledge and skill of Alcoa's large staff of "old foundry hands" who have been pouring castings and solving castings problems for many years.

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Your inquiries and problems on aluminum castings will receive unbiased, technically-sound answers based on which aluminum casting is best for your product and your cost figures . . . Alcoa makes die castings and permanent-mold castings, as well as the best sand castings.

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Aluminum weighs 0.10 # / cu. inch . . . only ⅓ as much as steel, brass, and bronze; only 40% as much as grey iron. Aluminum castings are lighter to handle, to machine, to assemble. Shipping costs of finished products are less.

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Aluminum cannot rust . . . requires no painting or other protection to keep it bright and shining. Can be given any decorative finish . . . electroplate, mechanical, or chemical . . . that other metals will take.

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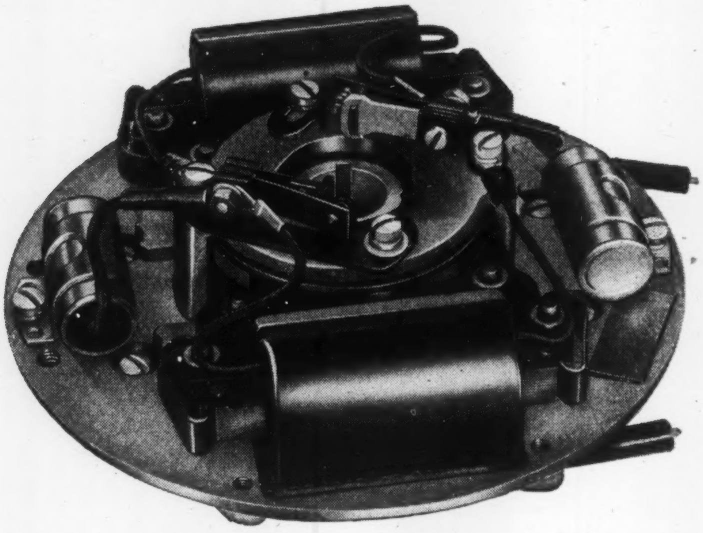
The New BENDIX-SCINTILLA CRANKSHAFT MAGNETO

FOR 1- AND 2-CYLINDER ENGINES



now available with or without flywheel

Bendix-Scintilla* now makes it possible for engine manufacturers to order their Magnetos *complete with flywheel* built to their specific needs. The extra convenience of obtaining the complete unit is added to the many advantages that have made the Bendix-Scintilla Crankshaft Magneto standard on so many new engines. Low cost, lighter weight, and performance that assures easier starting make it the outstanding development in the field. Write for details on this new product and its applications.

Check and compare ALL of these Features!

Available with or without flywheel • Lighter in weight • Low cost • Simpler in design • Assures easier starting • Coils permanently moisture-proof and dust-proof • Minimizes lubrication requirements • Pivotless breaker eliminates axle and bushing • Maximum efficiency at both high and low speeds

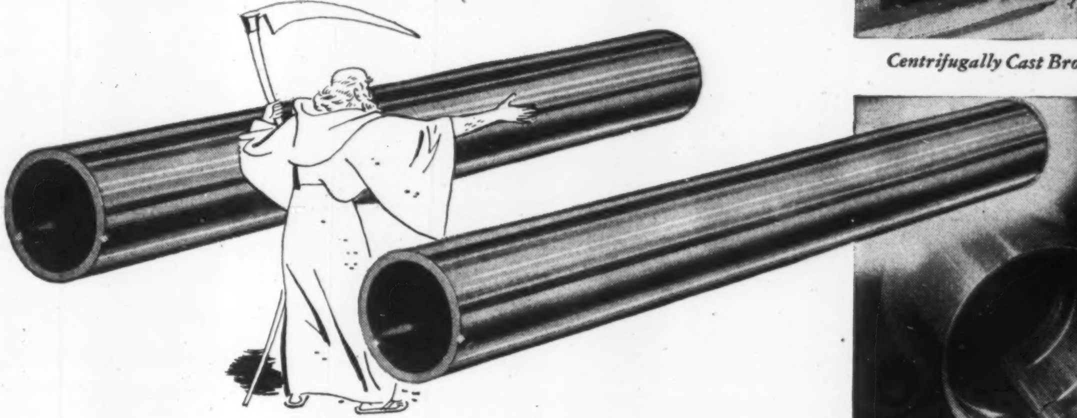
BENDIX SCINTILLA

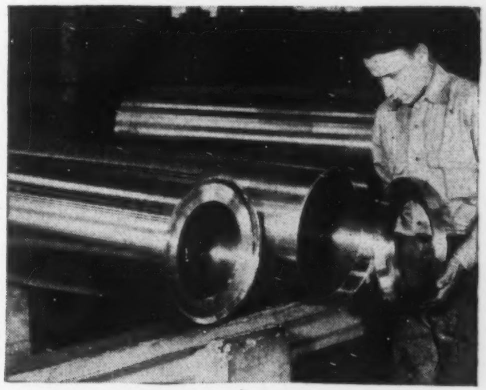
SCINTILLA MAGNETO DIVISION of Bendix AVIATION CORPORATION

SIDNEY, N. Y.

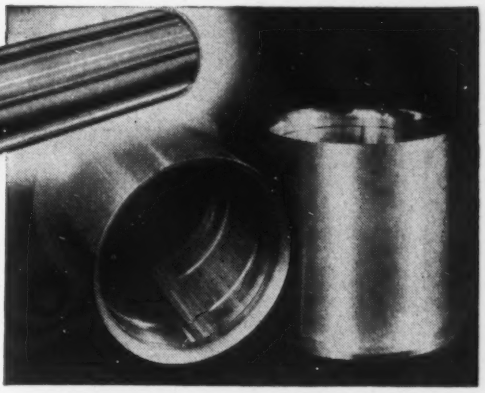
*TRADEMARK

Only time can tell them apart





Centrifugally Cast Bronze Printing Press Rolls



Centrifugally Cast Rubber Refiner Bearings

ROLLS and symmetrical machinery parts that are *centrifugally* cast by Shenango-Penn and those produced by ordinary methods may *look* identical. But time, time in service, will show you a big difference!

For the Shenango-Penn centrifugal process makes metals more homogeneous . . . gives them a generous extra measure of the very qualities that are so important in tough services: measurably greater tensile strength to better withstand stress and shock, greater density for prolonged wear-life and resistance to abrasion and corrosion, and a freedom from porosity, sand inclusions and blow holes that rounds out a picture of unsurpassed performance every time.

FREE BULLETIN No. 143 *tells all about our made-to-order centrifugal castings, ferrous or non-ferrous, small or large, rough, semi or finish machined; tells also about savings right from the blueprint stage on through.*

FREE BULLETIN No. 145 *tells all about our standard* centrifugally cast *bushing stock, in all popular sizes, always ready for immediate delivery.*

Send today for either or both of these free bulletins.

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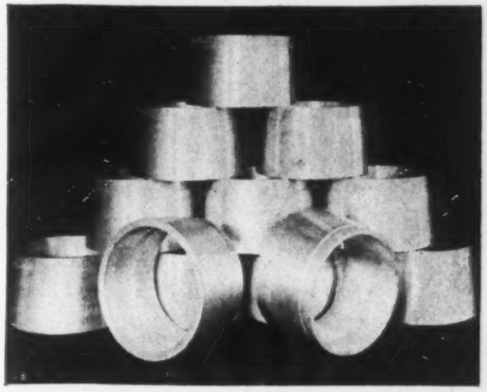
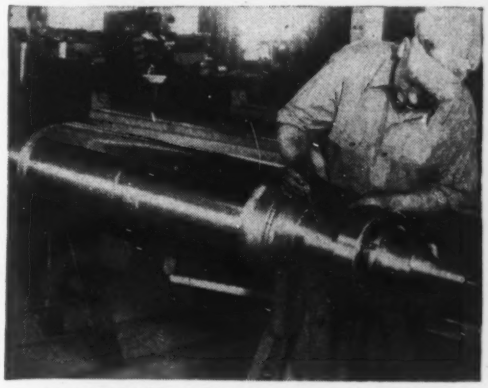
Executive Offices: Pittsburgh, Pa.



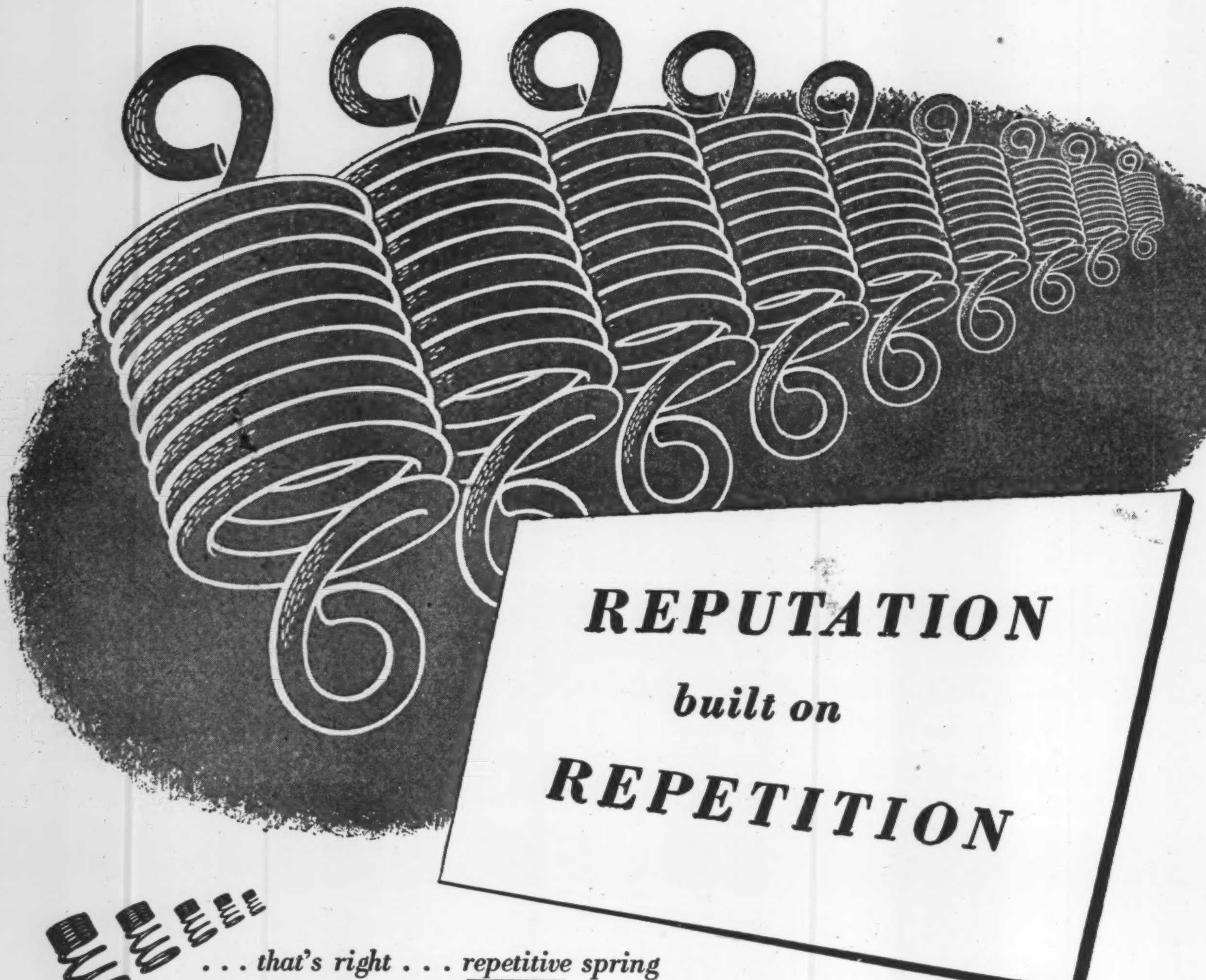
Centrifugally Cast Aluminum Parts, Rough Machined



Centrifugally Cast Textile Machinery Roll

SHENANGO-PENN

ALL BRONZES • MONEL METAL • ALLOY IRONS



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Uniformity to specifications on repeat orders . . .

Job engineering that results repeatedly in production savings on simple or complex spring designs.

Barnes customers are usually "repeat" customers . . . the reasons for which our representatives will be glad to tell. Ask them at the first opportunity.

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SMALL STAMPINGS • WIRE FORMS • HAIRSPRINGS • COLD ROLLED SPRING STEEL

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BRISTOL, CONN.

DIVISION OF THE ASSOCIATED SPRING CORP.
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"Make them STEEL"
"Make them SMALLER"
"PRE-LUBRICATE them"
"Prevent BURNOUTS"
"Give us QUIET motors"
"We want SMOOTH DESIGN"
"Make them LIGHTER"

The seven improvements asked for most in motors . . .

wrapped up and *PACKED IN STEEL!*

For years, motor users complained that no one motor had all the features they wanted most.

Westinghouse engineers surveyed motor users to find out exactly what they needed . . . and then tailored an entirely new motor to fit those requirements.

The result is the new, outstanding Life-Line Motor—the first truly all-steel motor made available to industry. Packed in its thick, protective steel housing are more benefits asked for by motor users than any other motor made today:

ALL-STEEL PROTECTION. All frames, feet and brackets are HEAVY STEEL.

UP TO 35% LESS SPACE PER HP. Life-Line Motors occupy less space per horsepower than any other standard motor.

UP TO 134% MORE TORQUE PER LB. As much as 134% higher starting torque per pound of motor . . . up to 116% higher maximum torque.

NO LUBRICATION NEEDED FOR 5 YEARS. Bearings are prelubricated . . . sealed against dirt and moisture.

STRONGER ELECTRICALLY. New insulating materials . . . new coil-winding techniques . . . new stator slot designs . . . give new record-setting electrical strength.

NEW, QUIET SMOOTHNESS. Life-Line Motors cut vibration and noise to new low limits for standard motors . . . satisfy many "special motor" requirements.

NEW, SLEEK LINES. Sleek lines and smooth finish discourage dust and dirt accumulations . . . harmonize with modern machine design.

Write for details. Westinghouse Electric Corporation, P. O. Box 2025, Buffalo 5, New York. J-21422

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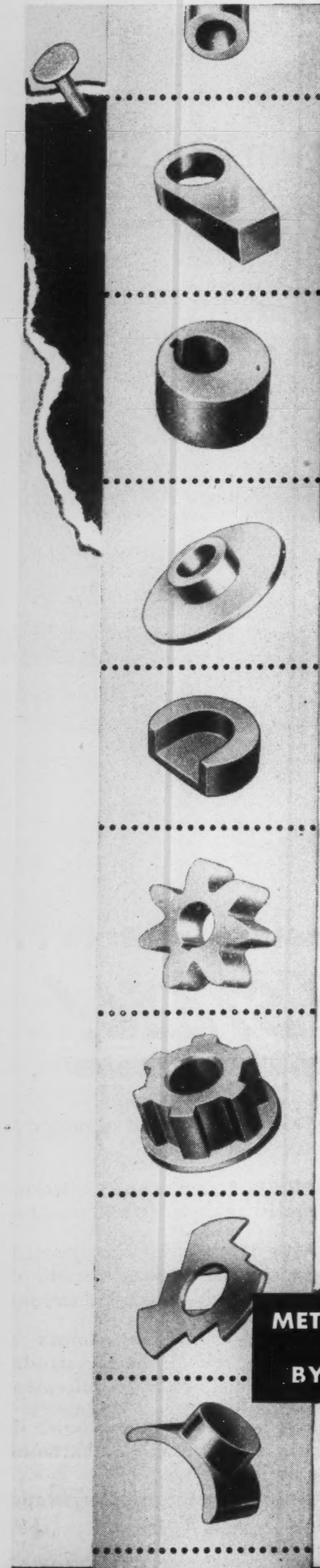
Life-Line motors

POWDER METALLURGY asks no favors



There was a time when manufacturers thought of powder metallurgy as just a "neat trick." They said, in effect: "That's very clever and no doubt difficult, but what can it do for me?"

Here at Moraine Products, we've worked to put powder metallurgy on a realistic foundation. We've made it stand on its own feet in dollars-and-cents competition with other methods of producing parts. And a growing list of large users proves that metal powder parts by Moraine fill a real need in today's industrial requirements.

Can metal powder parts by Moraine save you money? There is a good chance they can if the parts you need fulfill these conditions: 1) The shape permits good die fill and proper density; 2) the order is sufficiently large to justify initial tooling costs; 3) the physical properties and tolerances required are within the range attainable in normal factory production. Get a straight answer from Moraine Products.

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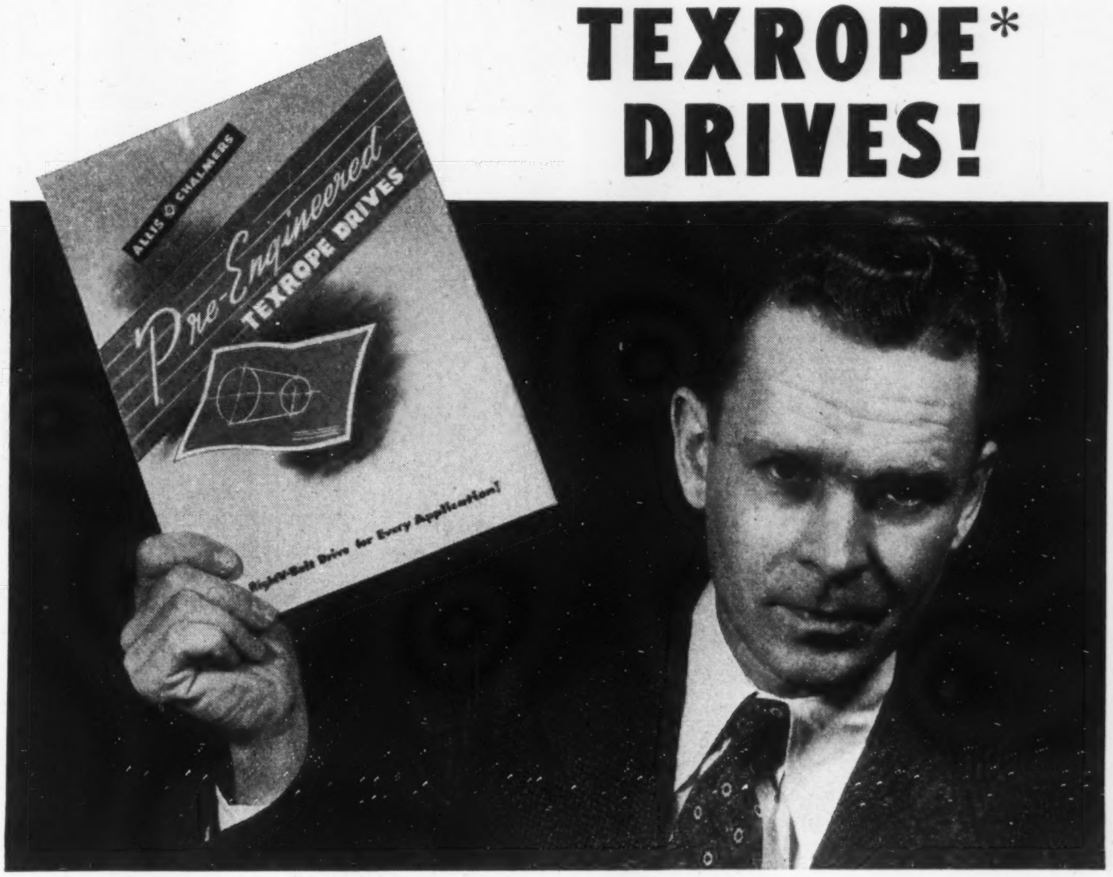
PARTS
BY MORAINE

MORAINE PRODUCTS
DIVISION OF
GENERAL MOTORS
DAYTON, OHIO

NEW MANUAL PRESENTS

Pre-Engineered

TEXROPE* DRIVES!



Selects Most Economical Drive for Any Installation!

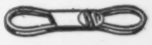
NEVER BEFORE has specification of the *right* V-belt drive been made so simple, so unerring. You turn to a page, run down a column, and there, in *one place* is the drive you need . . . number of grooves, diameters of sheaves, size of belt. No turning from table to table, no figuring.

These *Pre-Engineered* stock Texrope drives cover 90% of all requirements. Texrope engineers have carefully selected each one, using economical *stock* belts and sheaves. Each selection is the *one best drive* for a given requirement of power, speed and dimension.

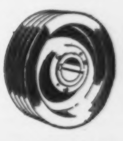
For the few cases not covered by *Pre-Engineered* stock drives, the manual provides complete, carefully arranged engineering data to make it easy to figure special drives.

Now Available . . . 144 pages, indexed, size 8½ by 11 inches. The most complete V-belt drive manual ever published. A book that only Allis-Chalmers can give you. Copies have been sent to many Texrope dealers and users. If you have not received one, write for Texbook No. 20P40. ALLIS-CHALMERS, MILWAUKEE 1, WIS. A 2333

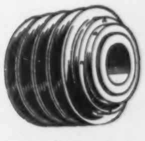
TEXROPE ..Greatest Name in V-Belt Drives



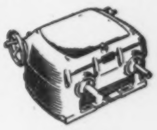
"Super 7" V-BELTS
Five Types — Sizes to suit every power transmission job.



Texsteel, Texdrive, "Magic-Grip"
— sheaves in a full range of sizes, grooves.



"Vari-Pitch" SHEAVES
Exact variations in speed, stationery or motion control.



SPEED CHANGERS
Speed variations up to 375% at the turn of a crank.

ENGINEERING
Finest V-Belt engineering talent in the world—at your call.

TEXROPE "Super 7" V-Belts result from the cooperative research of two great companies — Allis-Chalmers and B. F. Goodrich. They are sold only by A-C.

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A CENTURY OF SERVICE
to Industry
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Free-Machining

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Thinking about stainless? Consult Bethlehem. Here's why—

1. Our engineers will help you select the most suitable grade of stainless steel for the job . . . assist with any problems in processing, forging, heat-treating, machining.

2. Bethlehem stainless steels—Bethadur and the free-machining Bethalon grades—cover the entire range of standard AISI stainless steels, as well as many non-standard analyses.

3. These stainless steels are produced by an organization that has been making stainless for 30 years.

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BAR SECTIONS AND FINISHES

ROUND	SQUARE	FLAT	HEXAGON	OCTAGON
Hot-rolled; Forged Cold-drawn Centerless-ground Rough-turned; Polished	Hot-rolled Forged Cold-drawn	Hot-rolled Forged Cold-drawn	Hot-rolled Forged Cold-drawn	Hot-rolled Forged Cold-drawn

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

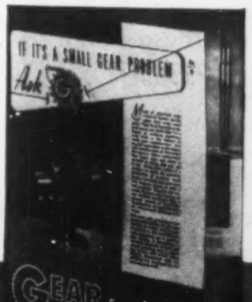
★ BETHLEHEM STEEL ★

FRACTIONAL HORSEPOWER GEARING
GS

WANT *BETTER QUALITY* IN THE SMALL GEARS YOU BUY?

FRACTIONAL HORSEPOWER GEARS that run *smoother,* that *last longer,* and that are more *uniform* have been a highly developed specialty of ours for more than 25 years! Applying *all* of our energies to designing and manufacturing the *world's finest* Small Gears has brought constant improvement in methods, machinery, materials and men. Perhaps the best measure of our success in making Small Gears *better* lies in the distinction of being the "world's largest exclusive manufacturers of Fractional Horsepower Gears!"

If your requirements call for a production run of Small Gears be sure to talk it over with a G.S. Engineer. Chances are his long experience and the unique facilities at his command may result in a better gear, quicker and at a moderate cost. Send us specifications, drawings or a sample gear today. Depend upon us for the right kind of service and cooperation.



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GEAR Specialties

Spurs • Spirals • Helicals • Bevels • Internals • Worm Gearing • Racks • Thread Grinding

2635 WEST MEDILL AVENUE • CHICAGO 47, ILLINOIS

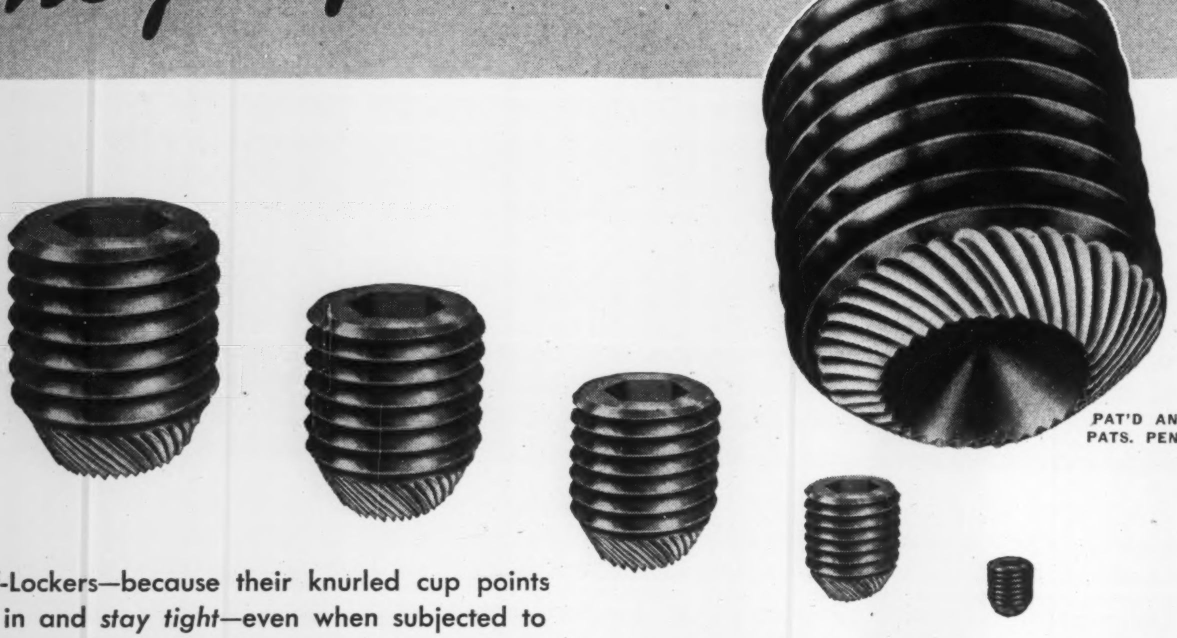
MEMBER OF AGMA

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS

UNBRAKO SELF-LOCKERS

Reg. U. S. Pat. Off.

They dig-in and "stay put"

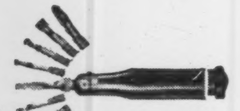


Self-Lockers—because their knurled cup points dig in and *stay tight*—even when subjected to the most chattering vibration. Yet, they can be backed out with a wrench and used *again* and *again*. That's why so many millions of these tough, dependable "Unbrako" Socket Set Screws with the Knurled Cup Points are used in industry. For complete information about these and other "Unbrako" Socket Screw Products . . . write for the "Unbrako" Catalog.

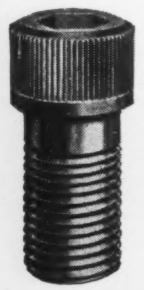
These "Unbrako" Screw Products are available in sizes ranging from No. 4 to 1½" in diameter and in a full range of lengths.

"Unbrako" and "Hallowell" Products are sold entirely through Industrial Distributors.

Knurling of Socket Screws originated with "Unbrako" in 1934.



You can't tighten or loosen socket screws without a hex socket wrench, so why not get our No. 25 or No. 50 "Hallowell" Hollow Handle Key Kit which contains most all hex bits.



"Unbrako" Socket Head Cap Screws with the knurled head save assembly time because the knurling provides a slip-and fumble-proof grip—though the fingers and head be ever so oily, therefore, they can be screwed in faster and farther before it becomes necessary to use a wrench. They can also be locked in place if heads are countersunk.

PAT'D AND
PATS. PEND.

The "Unbrako" Socket Set Screw with Knurled Threads is a most excellent Self-Locker, too, because the knurling, as shown, swages the threads when locking results. To be used with points such as: flat, dog, cone and oval which do not lend themselves to knurling.

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STANDARD PRESSED STEEL CO.

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OUTSTANDING FEATURES!

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BALL BEARING UNITS

- Permanently Sealed
- Self-Aligning
- No Housing Wear
- Quiet Operation
- Pre-Lubricated
- Streamlined Appearance

Flange Cartridge Unit

Cartridge Unit

Flange Unit

ONLY SEALMASTER BALL BEARING UNITS CAN ASSURE:

(1) Simplicity of Mounting—bearing unit can align itself in radius bored seat in housing, without distorting or reducing effectiveness of seal. Compact, one-piece housing reduces space required.

(2) Long Bearing Life—patented SealMaster seal keeps dirt out. Improved ball retainer traps lubricant around balls and races for best lubrication.

(3) Quiet Operation—patented locking pin prevents rotation of outer race, eliminates housing wear and prevents noisy bearings.

(4) Maximum Loads—Radial and Thrust—large balls and deep ball races permit radial and thrust loads, or any combination of the two.

(5) Minimum Maintenance—the centrifugal, labyrinth seal prevents loss of lubricant. Patented locking pin positions sealed housing for re-lubrication.

(6) Attractive, Streamlined Appearance—one-piece housing designed for trim appearance, maximum strength and minimum bulk.

Write for Catalog No. 845 for complete engineering data on complete line of SealMaster Ball Bearings.

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S-A MFG. CO.

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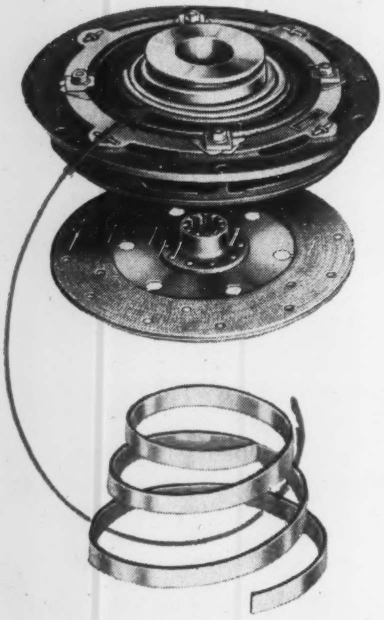
Wanted—

A conical spring that will be free of coil interference at any height of compression with the end coils always in parallel relation



THIS clutch, designed by the Lipe-Rollway Corporation, Syracuse, New York, required a conical spiral wound spring, close in load tolerance and rate. This conical spring had to be free of coil interference at any height of compressed position down to full flat compressed height.

When the springs that were being used proved unsatisfactory, American Steel & Wire Company engineers were called in. And they developed a series of cold wound spiral conical springs for this manufacturer's complete line of clutches. This includes both single and two plate multi-lever heavy duty clutches for commercial vehicles of 2½ tons and greater capacity. Today American Quality Springs are being used 100% as a standard component part of the clutches.

You may not need a spring like this for your product, but this is typical of the solutions we have provided for hundreds of troublesome spring problems.

When you buy springs be sure to get U·S·S American. They are your assurance of the finest quality. If you make your own springs, you'll find American Steel Spring Wire will produce the best results. Remember the *original* cost of springs is usually negligible, but *replacement* costs run high.

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Cleveland, Chicago and New York
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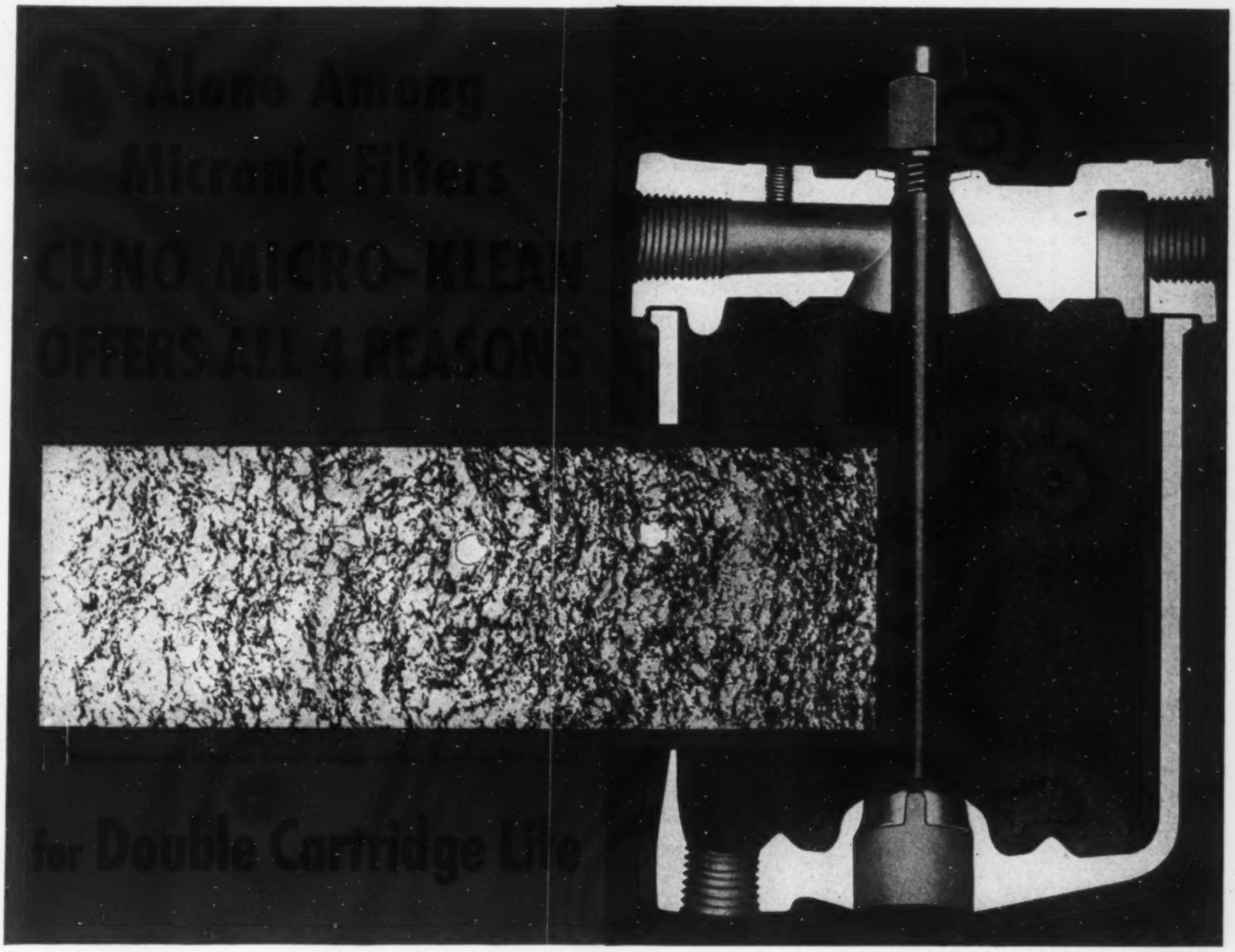

You can count on cutting cartridge replacement costs in half when filtering lube, hydraulic and fuel oil, water, water solutions and process liquids with Cuno MICRO-KLEAN.

Although other micronic filters may *appear* to be constructed this way, only the MICRO-KLEAN has *all four* features that give double dirt collection capacity, eliminate surface-loading and channeling, increase flow rates.

1. Graded Density in Depth — new method of "felting" creates a structure in which spaces between fibres become progressively smaller and more numerous approaching discharge surface. Smaller particles penetrate to varying depths — no surface sealing.

2. Controlled Fibre Distribution — gives consistent, uniform filtration characteristics.

3. Resinous-Impregnated and Polymerized — each fibre bonded in position to give structural strength. No channeling, rupturing, shrinking or distortion.

4. 85 to 90% Porosity — no structural components that waste space.

Send coupon today for free facts to fit your installation.

FILTERS FOR NEW EQUIPMENT... CARTRIDGES FOR REPLACEMENT

Cuno MICRO-KLEAN filters are offered in sizes for every job — connections from 3/8 in. IPS to 6 in. flanged . . . capacities from a few gpm to 850 gpm . . . single or multiple cartridge units to handle full flow. MICRO-KLEAN cartridges fit other makes of filters, special lengths available for built-in installations.

DIESEL ENGINE MANUFACTURER ADOPTS MICRO-KLEAN BECAUSE

Installation of 32 Micro-Klean cartridges in 800 H P engine test stand filter provided 175 hours of continuous operation with only 2 PSI pressure drop through filter as compared to previous record of 10 PSI drop after only 150 hours operation at which point replacement was necessary. Micro-Klean cartridges continued in operation for 283 hours before requiring replacement.

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Fluid Conditioning

AUTO-KLEAN General service down to .0035 in. Disc-type. Continuously cleanable.

FLOW-KLEAN. For highly abrasive solids down to .0025 in. Wire wound. Continuously cleanable.

MICRO-KLEAN. Micronic-type. Molded fibre "Graded Density in Depth" cuts replacement costs.

COOLANT-KLEAN Low cost unit filtration of grinder coolant. Fabric type element.

CUNO ENGINEERING CORPORATION,
203 South Vine Street, Meriden, Conn.

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☐ Lubricating Oil	☐ Water and Water Solutions	☐ Hydraulic Oil
☐ Compressed Air	☐ Fuel Oil	☐ Acids

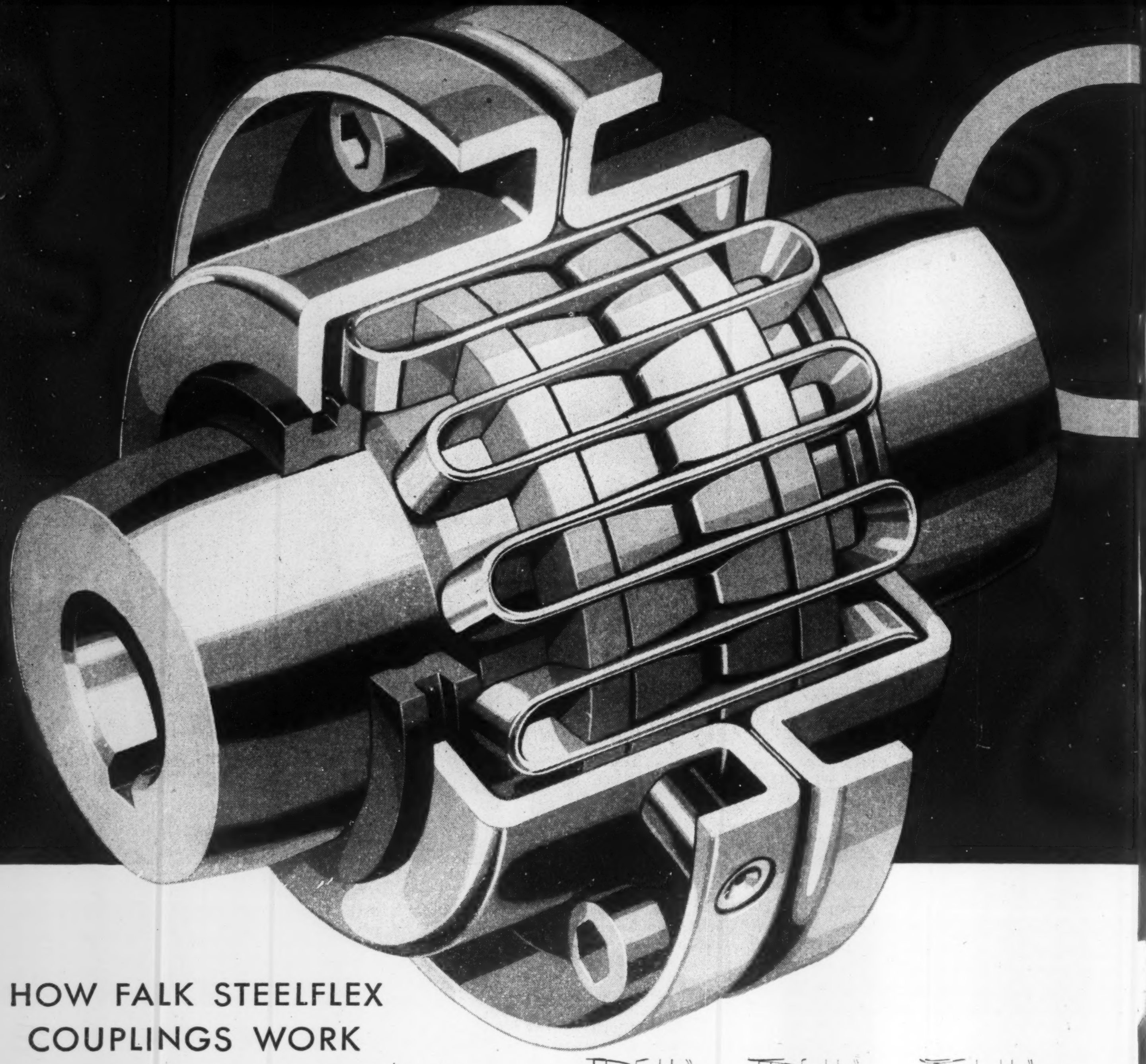
Write any other fluid-cleaning problems here..............
....

Send free sample cartridges for installation in:..............
(filter make)

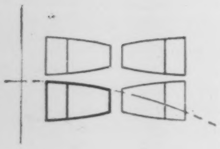
Name.............................Title ....

Company.......... ....

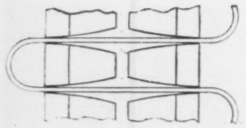
Address...



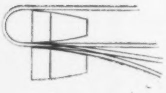
HOW FALK STEELFLEX COUPLINGS WORK



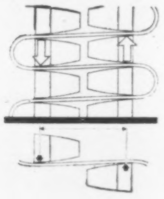
1. Grooves, in a precise arc, and with a radius and length proportional to the capacity of the coupling, are cut into two identical hubs of moderately high carbon steel—forged of Falk alloy cast steel.



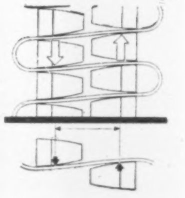
2. These grooves provide a slot for a grid member made of chrome alloy steel with an elastic limit of 180,000 pounds per square inch and an ultimate strength of 220,000 pounds per square inch.



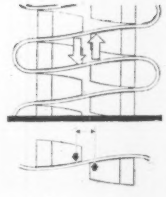
3. This grid fits snugly into the curved grooves, which provide a scientifically cut bearing surface for the grid. This bearing surface extends from the outer to the inner edge of the grooves. The grid bears on the grooves in proportion to the load.



4. Under light loads, the grid bears only at the outer edges of the grooves. This permits a long, free, elastic span between the outer edges of both hubs. Power is transmitted through almost the entire length of the grid rung.



5. Under normal loads, the grid bears on a larger area of the grid grooves and the span of the grid run is shortened. It transmits more power and maintains its capacity to absorb shocks and dampen vibration.



6. Under peak loads, the grid rungs bear over almost all of the curved surfaces of the grooves. The span of the grid rung becomes very short. Under the impact of shock loads the grid flexes and continues to transmit power smoothly.

Twenty-two years of user experience in couplings have given Falk the service factors which indicate the proper cushioning in a circular plane. They transmit power smoothly, reduce shock, dampen vibration, cushion peak loads between power source and producing unit. Above all, they furnish the highest protection to your connected machinery—with a consequent reduction in maintenance costs, production delays and breakdowns. . . . Falk Steelflex Couplings are readily available. Stocks are maintained by carefully selected distributors at strategic locations.

Do you Make the Costly Mistake of Selecting Couplings by Bore Size Only?

- Many a capable plant man in industry who would scoff at the idea of buying a hat on the basis of its size *alone* fails to use comparable judgment when selecting a coupling to protect his valuable machinery!

He often selects couplings on the false assumption that *bore size alone* is an adequate specification. And that can be a costly mistake indeed!

We at Falk recognize that, in addition to bore size, three vital factors should determine which Falk Steelflex Coupling to choose:

- **FIRST, the application for which the coupling is required.**
- **SECOND, the horsepower the coupling must transmit.**
- **THIRD, the speed (r.p.m.) at which it is to operate.**

Only by this "three-dimensional" method can you make sure that the couplings you select will give you the proper performance and durability in service you have a right to expect.

* * *

Falk Steelflex Couplings offer three distinct advantages which combine to lower your coupling costs:

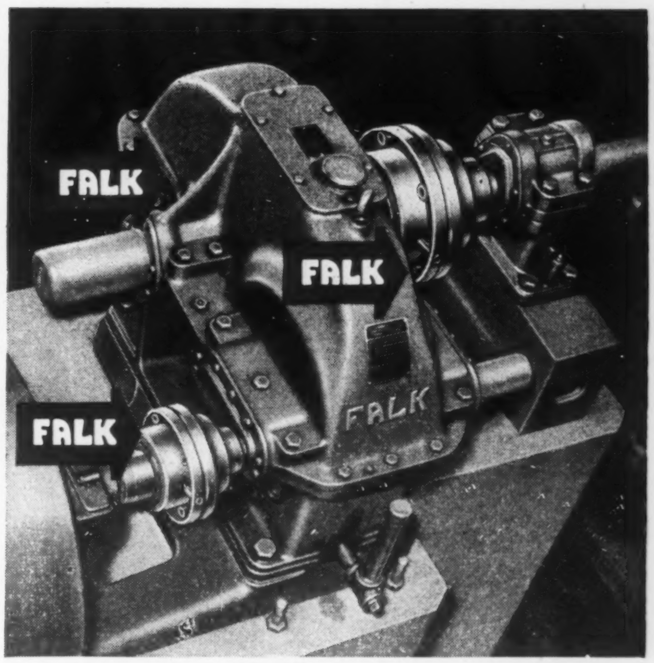
Torsional Resilience: The grid-groove design permits spreading of the peak of shock loads over a longer time, thus reducing stresses in your connected machinery.

Flexibility: Falk Steelflex all-steel construction assures greater flexibility in actual service . . . and prolongs machinery life.

One Type for Most Uses: Falk Steelflex Couplings meet practically all industrial installation requirements. This fact facilitates buying, replacing, or servicing couplings promptly.

* * *

Our bulletin 4100 tells you what you should know about Falk Steelflex Couplings. Write for it today.



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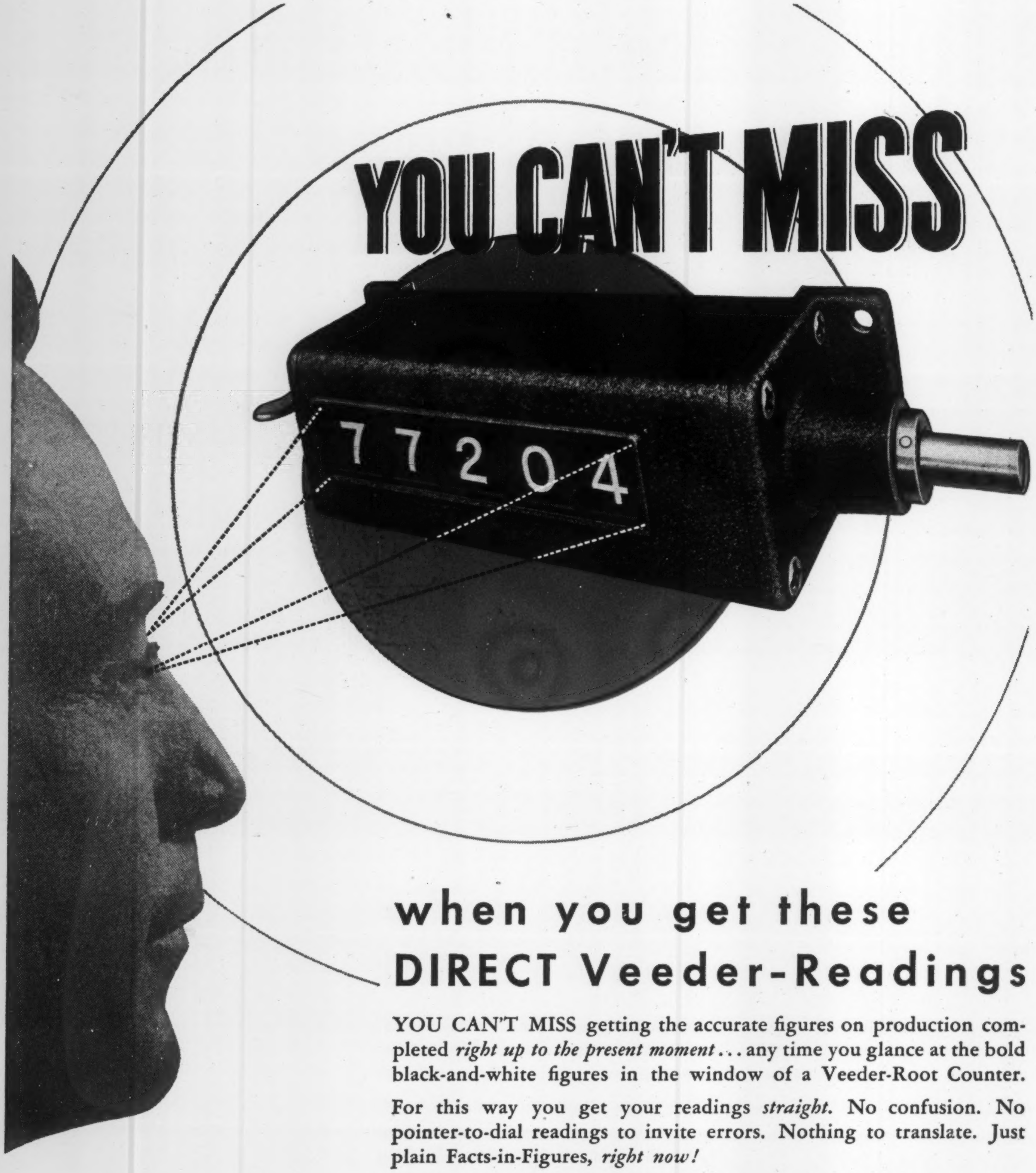

when you get these DIRECT Veeder-Readings

YOU CAN'T MISS getting the accurate figures on production completed *right up to the present moment*... any time you glance at the bold black-and-white figures in the window of a Veeder-Root Counter.

For this way you get your readings *straight*. No confusion. No pointer-to-dial readings to invite errors. Nothing to translate. Just plain Facts-in-Figures, *right now!*

There are Veeder-Root Devices, mechanically and electrically operated, to put everything under *Count*rol, including whatever unit or motion *you* want to count. They can be built into products to increase their utility and sales... and they can be easily attached to machines now in use. In fact, you can even have your Veeder-Readings *flashed* from factory to office, if you wish. How? It's easier to *show* you and we'll be glad to do just that. Write.

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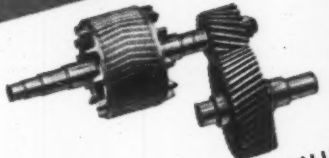
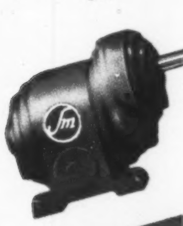
GEARED

to the correct production speed



UNDIVIDED RESPONSIBILITY . . . Experienced engineering — precision helical gears — liberal ball bearings — splash lubrication — and rugged construction are combined in this one compact, sturdy, dependable unit.



Improved Sterling Slo-Speed geared motors are available with single and double reduction gears in a wide variety of ratios.

Use the improved Sterling Speed-Trol—where "speed control" — faster or slower — is required.

Use the improved Sterling Klosd general-purpose motor — where one best constant normal speed is required.

Improved

STERLING SLO-SPEED

BALANCED DESIGN FOR EVERY HORSEPOWER RATING

Sterling is as well known for its precision gears as for the advanced engineering in its electric motors. From power intake to drive shaft, Sterling makes motor, gears, and all parts in one modern plant — giving you a highly efficient, slow-speed power unit for the "one best" correct production speed. Thousands of satisfied users are increasing plant profits with Sterling Slo-Speed geared motors.

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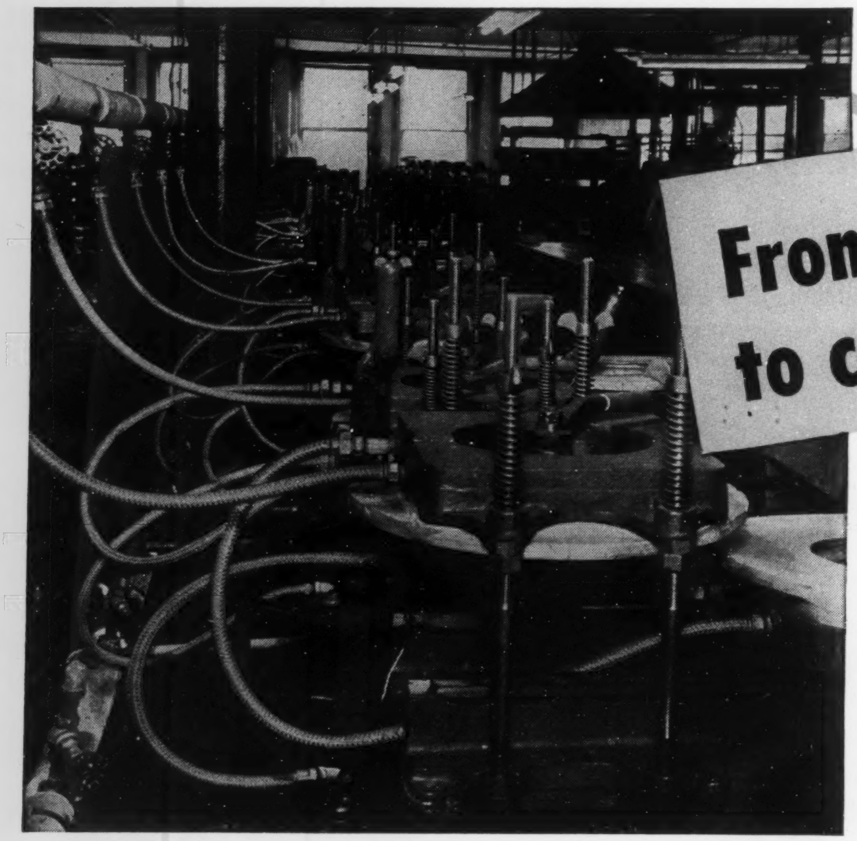
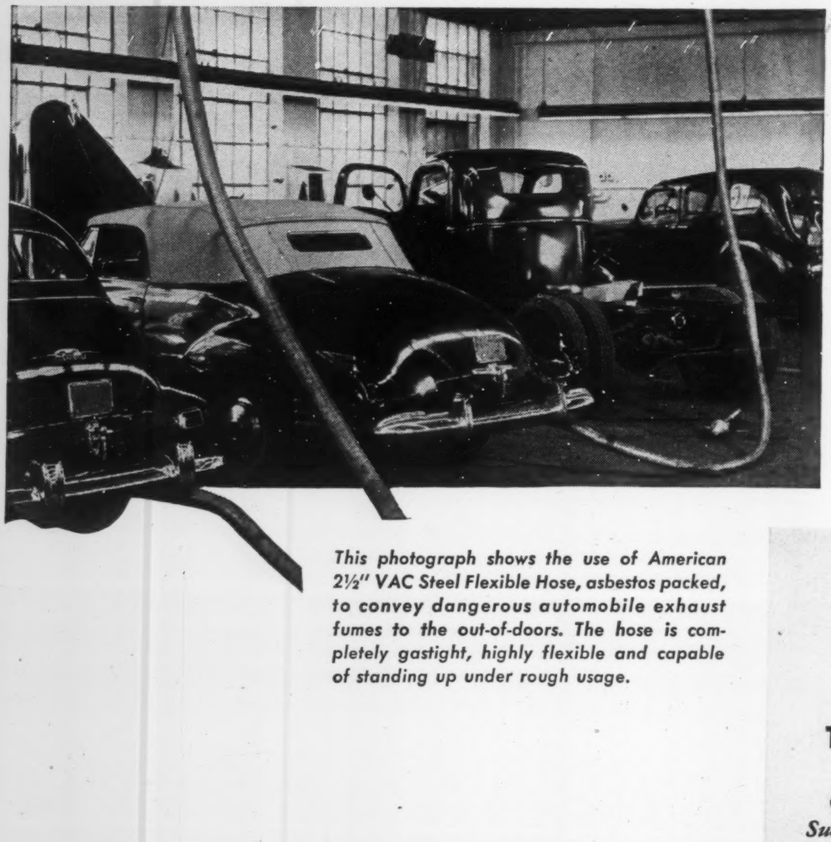
From hat making to car repairing



American Seamless Flexible Bronze Tubing is used to carry live steam under pressure, on this battery of brim laying machines at the M. A. Cuming Company, New York City hatters. The flexibility of Seamless permits free movement of the lower platens of these machines.



This photograph shows the use of American 2½" VAC Steel Flexible Hose, asbestos packed, to convey dangerous automobile exhaust fumes to the out-of-doors. The hose is completely gastight, highly flexible and capable of standing up under rough usage.

Flexible Metal Hose increases efficiency

YOU'LL FIND American Flexible Metal Hose or Tubing, in a wide variety of forms, doing thousands of different jobs. Whether *your* particular problem is one of vibration, misalignment or connecting moving parts—in conveying steam, oil, water, other liquids, semi-solids or gases—an "American" flexible metal connector will do the job efficiently and economically.

American Flexible Metal Hose is made in four spirally wound types, from brass, bronze, aluminum, steel and other metals, in sizes ranging from ⅛" to 12" I.D. American *Seamless* Flexible Metal Tubing, ordinarily made in bronze, is as leakproof as seamless pipe and as flexible as garden hose; standard in sizes ⅛" to 4" I.D.

Any of these "American" products can be supplied complete with end fittings exactly to your specifications. For detailed information, write for descriptive literature.

47295

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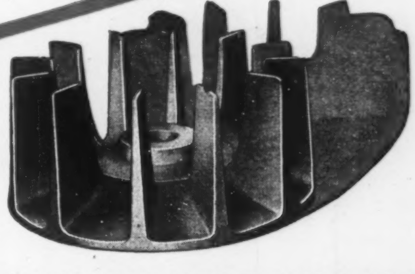
Don't puzzle needlessly over whether your aluminum castings should be made by permanent mold, sand or die casting process. Ask Permite aluminum engineers to work out the correct answer according to your particular product needs, quantity and cost requirements.

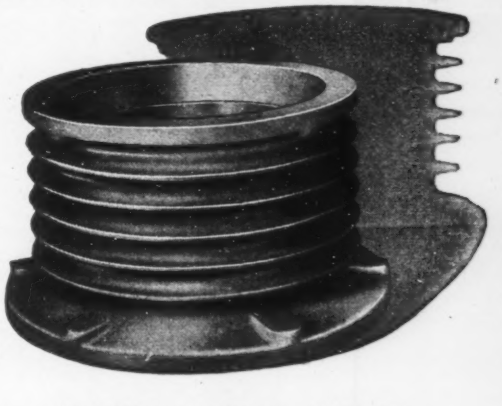
The quarter-century of experience of Permite engineers in working with aluminum alloy castings will be placed at the service of your own design and production engineers and cost estimators. Recommendations will be unbiased, as all three processes are used in the modernly equipped Permite aluminum foundries.

Shape of the part, whether simple or complex, section thickness, dimensional accuracy required, necessary mechanical properties, surface finish desired, number of castings needed, production rate expected, approximate cost ratios — these are some of the important factors studied in determining casting methods.

Choice of the right type of aluminum castings can make a big difference in the production rate and cost of your product. So put the problem up to us. Don't hesitate to tell us about your parts requirements and to ask for recommendations and cost estimates.



PERMITE PERMANENT MOLD CASTING



PERMITE SAND CASTING

PERMITE DIE CASTINGS

PERMITE

ALUMINUM INDUSTRIES, INC.

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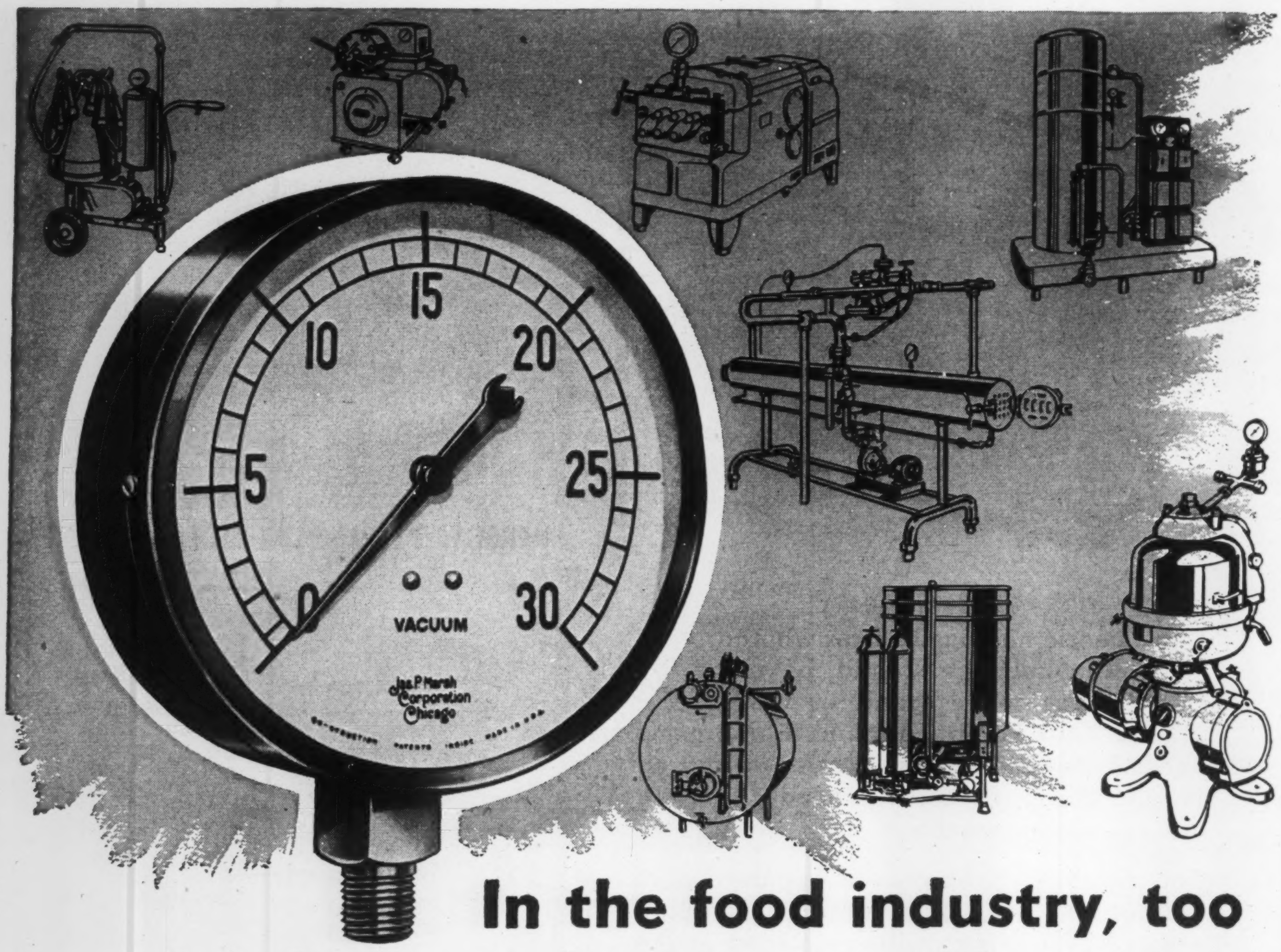
ALUMINUM PERMANENT MOLD, SAND and DIE CASTINGS...HARDENED, GROUND and FORGED STEEL PARTS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VACUUM
Jas. P. Marsh Corporation Chicago

In the food industry, too leading machinery manufacturers rely on *Marsh* . . . .

Manufacturers of milk processing, canning, packing and similar equipment know the vital importance of highly dependable, extremely accurate pressure and vacuum indication. That is why Marsh Gauges are on the preferred list in the food-machinery field . . . are chosen as standard equipment by the largest producer of machinery of this type and by 32 other leading food-equipment manufacturers.

The wide range of conditions found in the highly varied processes of the food industry are a real challenge to pressure gauge quality, so the preference shown by this industry is an impressive tribute to Marsh design and construction. However, it is no more significant than the preference shown by manufacturers in many other fields.

These manufacturers who use gauges as standard equipment have found in Marsh instruments the uncompromising quality that has made them "The Standard of Accuracy." In short, they have found the kind of product they are proud to make part of their own product!

Consider this when you choose a gauge or when you purchase equipment requiring a gauge. Insist on the Gauge that is preferred by the most discriminative users of pressure gauges—MARSH.

MARSH ALONE HAS THE "RECALIBRATOR"

. . . quickest and best way to correct a gauge that has been knocked out of adjustment by improper handling.

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"TRULY LIFE-TIME MOTORS"
B-LINE
"B-Line" out in Front

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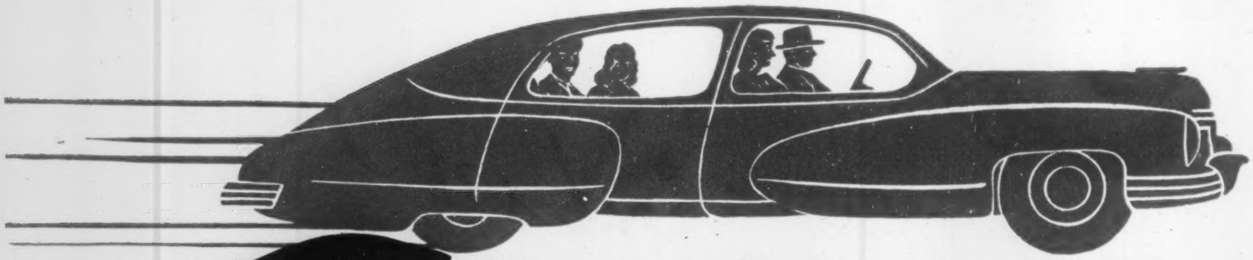
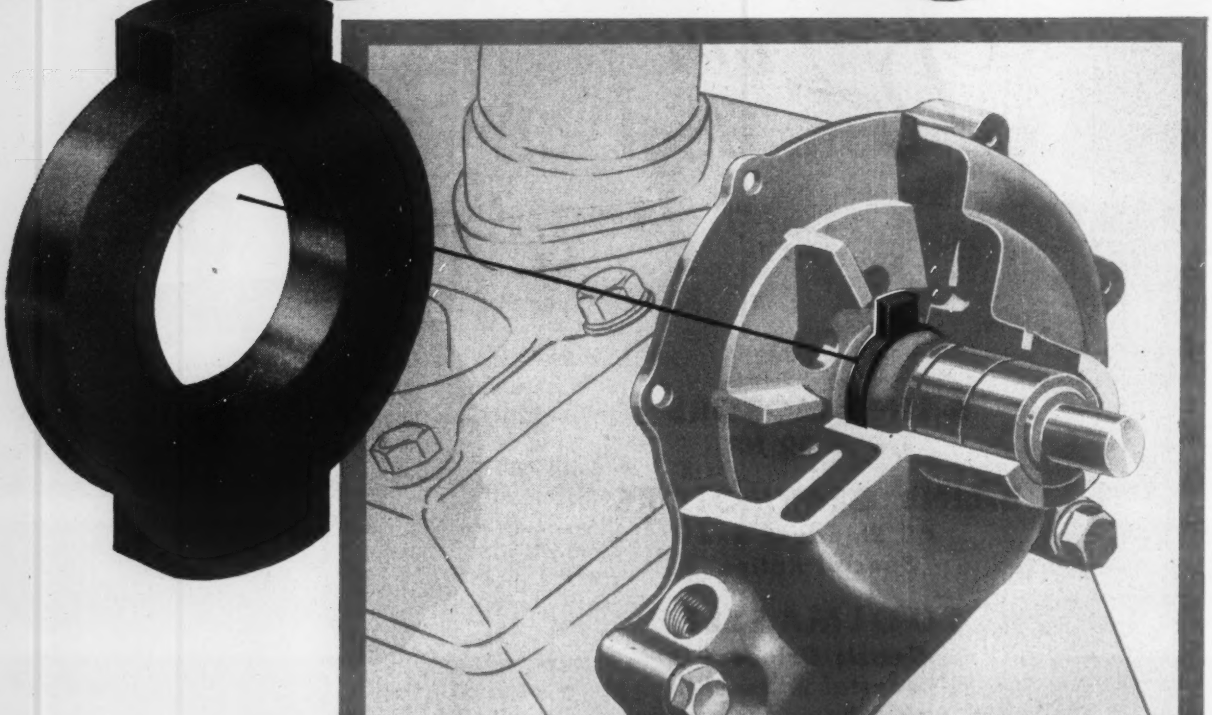
(CARBON-GRAPHITE)
roll ahead in dependability

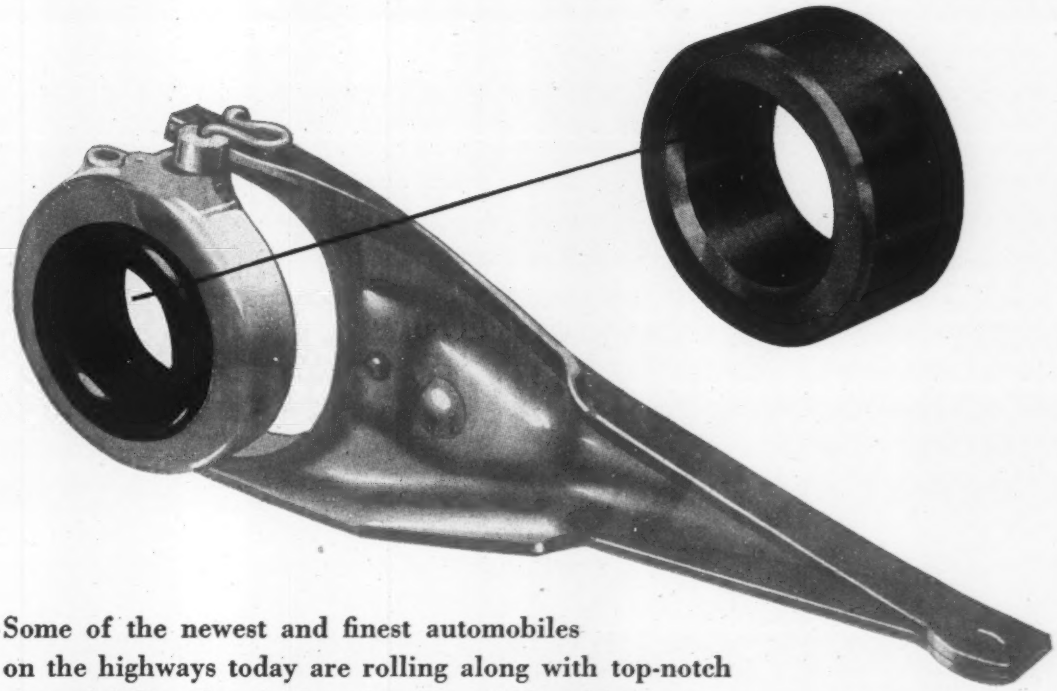
large automobile manufacturer* specifies Graphitar bearing for clutch throwout assembly and Graphitar seal for water pump





*Name Withheld by Request

THE UNITED STATES GRAPHITE



Some of the newest and finest automobiles on the highways today are rolling along with top-notch dependability that is due, in part, to Graphitar.

For example, one large automobile manufacturer* *specifies Graphitar* for two vital applications—the bearing in the clutch throwout assembly and the seal in the water pump. *Why?* Because Graphitar, a carbon-graphite material, requires no lubrication. It is hard, with tough wearing qualities that defy friction. It is unaffected by chemicals. It will not melt or fuse and is dimensionally stable despite sudden and extreme temperature changes. These properties help to maintain the reputation for unfailing performance that this popular car has earned.

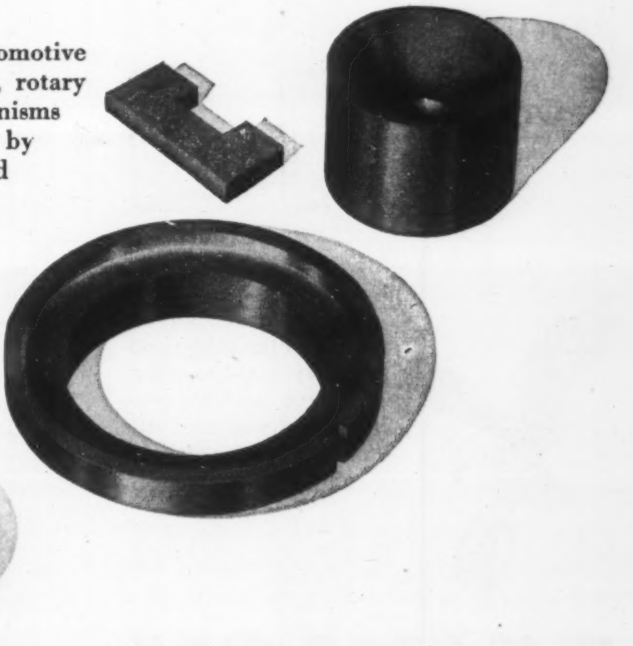
GRAPHITAR IS VERSATILE

(CARBON-GRAPHITE)

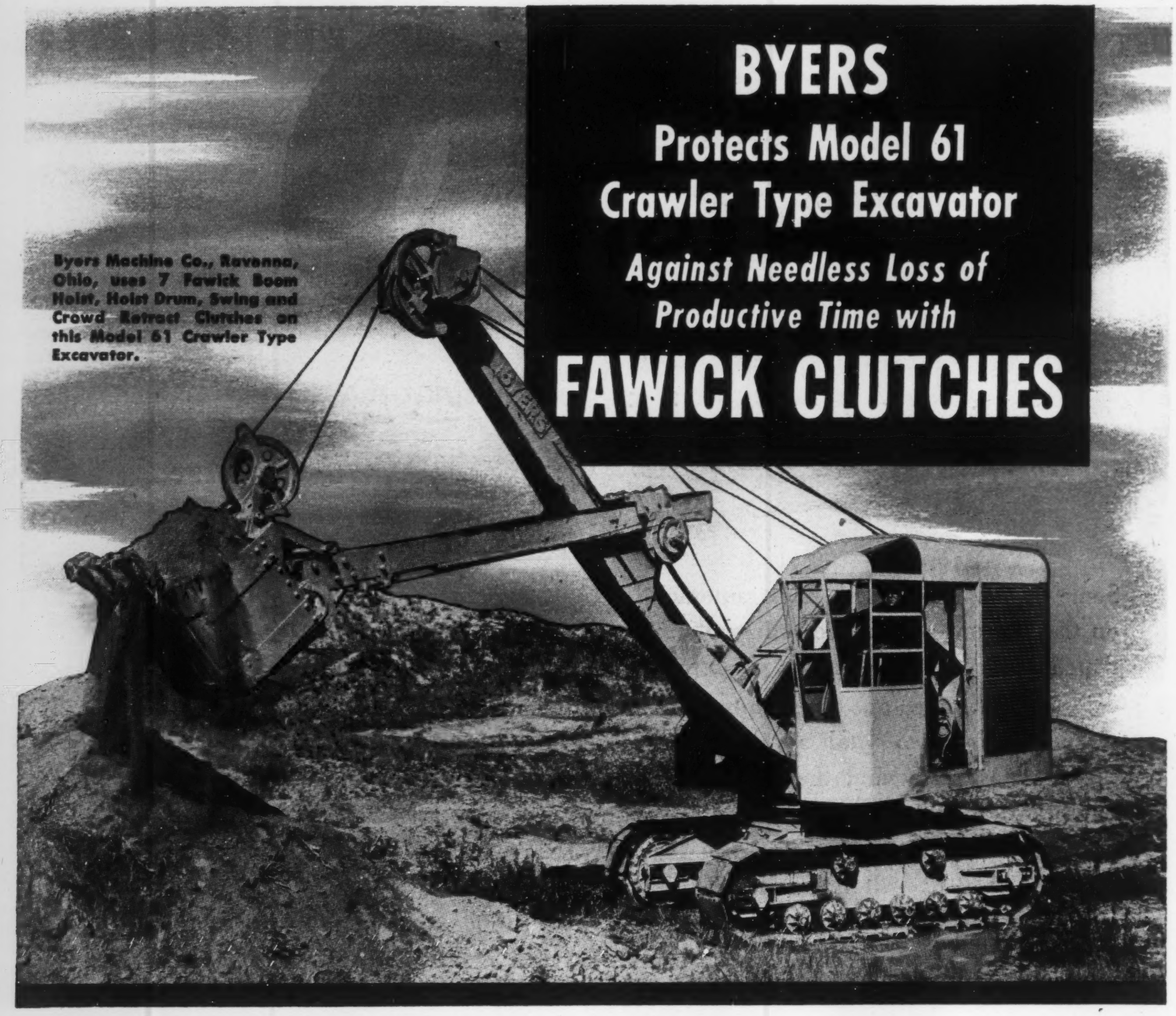
The use of Graphitar is by no means confined to the automotive industry. Manufacturers of sump pumps, steam turbines, rotary pressure joints, air compressors, and many other mechanisms are increasing the *efficiency* of their products at less cost by equipping them with Graphitar seals, rings, bearings, and vanes. Graphitar also has several applications in the glass industry, including molds and transfer pads.

We can mold Graphitar parts to any practical shape and size and finish them to close tolerances—*.0005" in small sizes.* Send us sketches or descriptions of your products and our engineers will recommend the use of Graphitar parts where they will improve mechanical performance and save you money.

ASK FOR 44-PAGE ILLUSTRATED CATALOG.



COMPANY • SAGINAW, MICHIGAN



BYERS

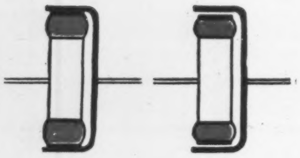
Protects Model 61 Crawler Type Excavator

Against Needless Loss of Productive Time with

FAWICK CLUTCHES

Byers Machine Co., Ravenna, Ohio, uses 7 Fawick Boom Hoist, Hoist Drum, Swing and Crowd Retract Clutches on this Model 61 Crawler Type Excavator.

FAWICK CLUTCHES
WORK LIKE THIS . . .



Compressed air expands the rubber-and-fabric gland to engage clutch, any degree of "grip" you need. Release the air and clutch disengages instantly.

Fawick Clutches give machine users these unique, money-saving advantages:

- **Torque controlled, shocks absorbed by a cushion of air.**
- **No strain on any part of machine in quick starts and stops under load.**
- **No arms, levers or springs to wear or break.**
- **No adjustments to make—no lubrication required.**

The net results are that the entire machine is protected against needless loss of productive time—and maintenance costs are held to the minimum.

And that is precisely why so many leading manufacturers of both light and heavy-duty equipment are building Fawick Airflex and Air-ring Clutches into their machines today.

If you want to solve your clutch, slip clutch, brake and power take-off problems for keeps, let our Engineering Department give you our recommendations for your machines.

FAWICK AIRFLEX CO., INC.
9919 Clinton Road • Cleveland 11, Ohio
***In Canada,* Renold-Coventry Ltd., Montreal, Toronto, Vancouver, Quebec**
***In Britain,* Crofts Engineers, Ltd., Bradford, England**

FAWICK *Airflex* CLUTCH

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THE NEOPRENE NOTEBOOK 38

FACTS ABOUT NEOPRENE FOR THE ENGINEER

THE MANUFACTURE OF PRODUCTS FROM NEOPRENE LATEX

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New resilient machine mountings isolate unwanted vibrations.
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Hydraulic hose made of neoprene helps make production records.
(Issue No. 37, page 202)

New gaskets combine properties of asbestos and neoprene for improved heat resistance.
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. . . THROUGH CHEMISTRY

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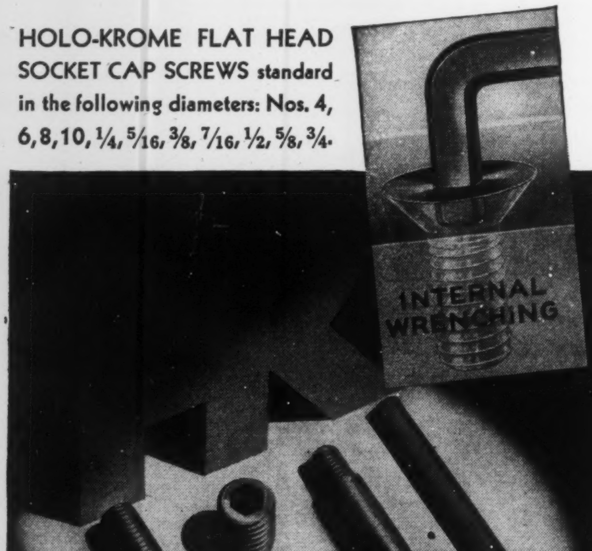
FLAT HEAD
SOCKET CAP SCREW

HOLO-KROME FLAT HEAD SOCKET CAP SCREWS standard in the following diameters: Nos. 4, 6, 8, 10, 1/4, 5/16, 3/8, 7/16, 1/2, 5/8, 3/4.



Another achievement of the Holo-Krome exclusive patented Completely Cold Forged method. Not drilled, broached or machined. The H-K new line of Flat Head Socket Cap Screws is made from special analysis alloy steel scientifically heat treated. Threads (Class 3 Fit) are accurate to lead and pitch. Sockets are of true hexagonal shape uniformly accurate to their full depth, smooth regular walls, well defined corners. H-K internal wrenching feature permits quick and positive tightening. . . . As always, H-K Flat Head Socket Cap Screws are only sold thru Holo-Krome authorized stock carrying distributors.

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SOCKET SCREWS
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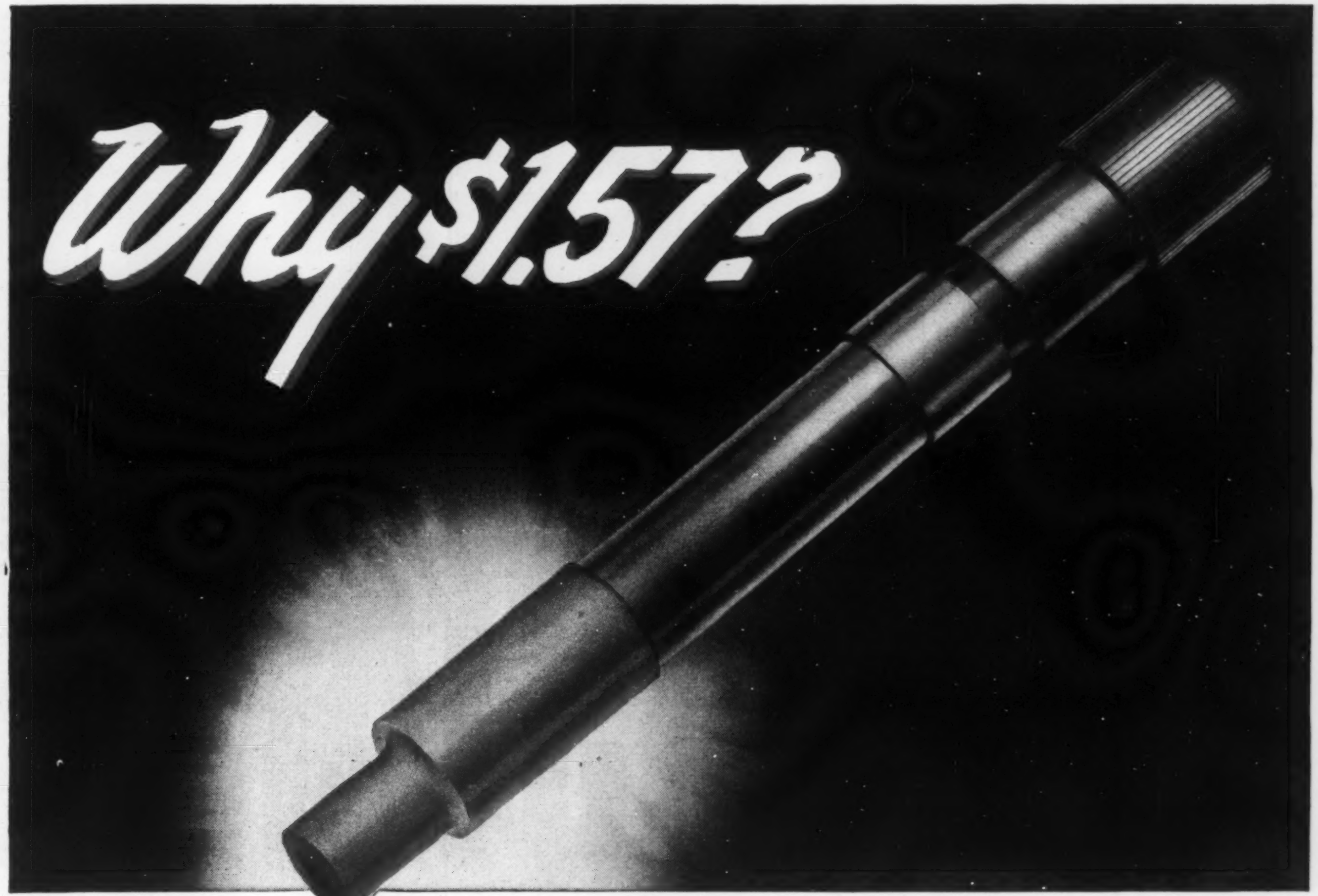
THE HOLO-KROME SCREW CORP., HARTFORD 10, CONN., U. S. A.



Harden it for 10¢ with TOCCO

PROGRESSIVE *Kearney & Trecker Corp.,* Milwaukee, Wisc., reports the following savings by TOCCO hardening the above saddle clamp eccentric of their Milwaukee Milling Machine:

	FORMER METHOD	TOCCO
Heat treating	$ 0.721	$ 0.099
Straightening	0.752	0.000
Cleaning	0.100	0.000
Total Cost	$ 1.573	$ 0.099

Saving . . . $1.47 per piece

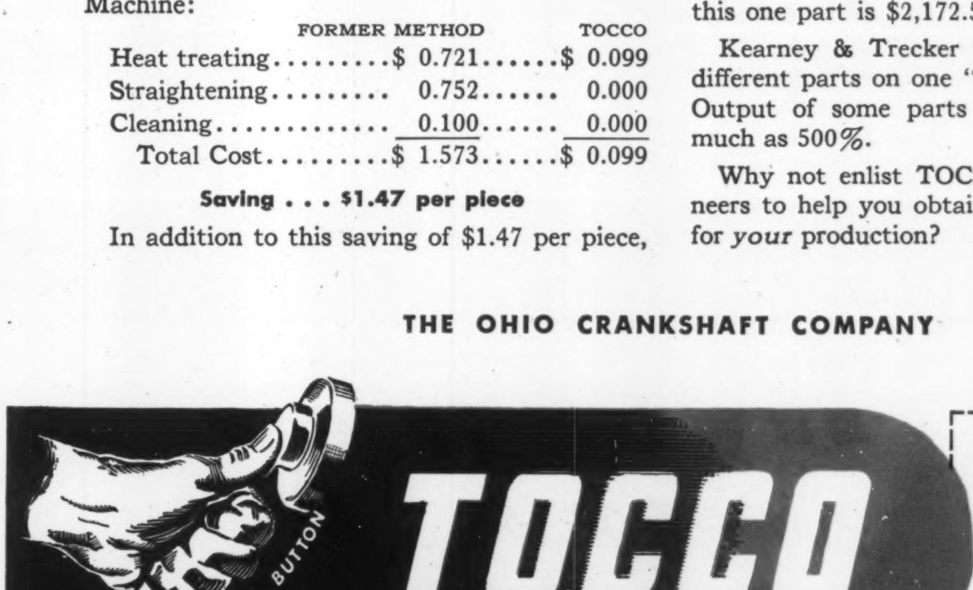
In addition to this saving of $1.47 per piece, TOCCO made possible a switch from alloy steel to S.A.E. 1045 steel, saving $0.110 in material cost per piece.

Total saving on each run of 1375 pieces for this one part is $2,172.50.

Kearney & Trecker hardens a total of 140 different parts on one "TOCCO JR." machine. Output of some parts has been increased as much as 500%.

Why not enlist TOCCO's experienced Engineers to help you obtain similar improvements for *your* production?

THE OHIO CRANKSHAFT COMPANY



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The Ohio Crankshaft Co.
Dept. B-5, Cleveland 1, Ohio

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SUPERB

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is only one of Hycar synthetic rubber's unusual and valuable properties. Others are listed in the box at the right.

But most important, these properties may be had in an almost limitless number of combinations, each designed to meet specific service conditions of the finished Hycar part.

Our files contain more than 5000 recipes for Hycar compounds—each compound engineered to do a certain job. Parts made from HYCAR have seen service in *every* industry, giving long life, dependability, and economical operation.

That's why we say, ask your supplier for parts made from Hycar. Test them in your own application, difficult or routine. You'll learn for yourself that it's wise to use HYCAR for long-time, dependable performance. For more information, please write Department **HN-11** B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio.

CHECK THESE SUPERIOR FEATURES OF HYCAR

1. ***EXTREME OIL RESISTANCE*** *— insuring dimensional stability of parts.*
2. ***HIGH TEMPERATURE RESISTANCE****—up to 250° F. dry heat; up to 300° F. hot oil.*
3. ***ABRASION RESISTANCE****—50% greater than natural rubber.*
4. ***MINIMUM COLD FLOW*** *— even at elevated temperatures.*
5. ***LOW TEMPERATURE FLEXIBILITY*** *— down to —65° F.*
6. ***LIGHT WEIGHT*** *— 15% to 25% lighter than many other synthetic rubbers.*
7. ***AGE RESISTANCE****—exceptionally resistant to checking or cracking from oxidation.*
8. ***HARDNESS RANGE****—compounds can be varied from extremely soft to bone hard.*
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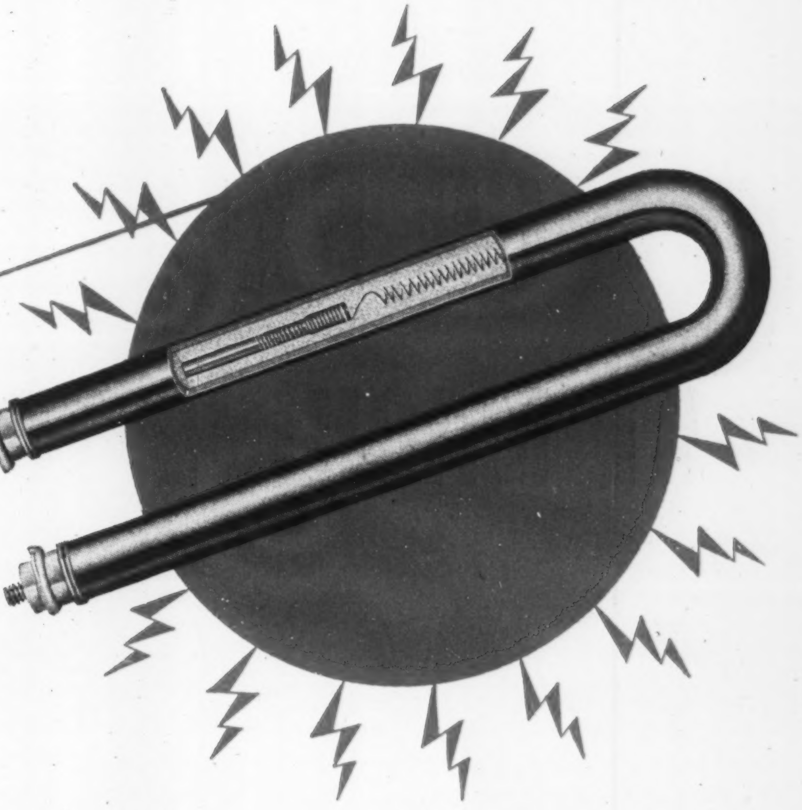
The Hottest News In Electric Heat!



Now YALE . . . famous for its locks and materials handling equipment... gives you an enclosed electric heating element that you *know* will give *uniform* heat.

That's the word we want you to associate in your mind with YALE—*uniform.* We're putting into this heating element the same craftsmanship that made "YALE" the No. 1 name in locks . . . in order to make "YALE*lectric*" the No. 1 name in electric heat. For example, YALE's famous manufacturing controls result in:

1. uniform distribution of the refractory within the sheath for *uniform insulation*
2. accurately centralized location of the resistor—equidistant from the sheath throughout its length — for *uniform heat transfer*

We are now in production at our Buffalo plant on the first of a complete line of electric heating units. You can get immediate shipment on the YALE*lectric* Rod-Type Heating Unit.

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THE BRIGHT SPOT IN ELECTRIC HEATING

THE YALE & TOWNE MANUFACTURING COMPANY

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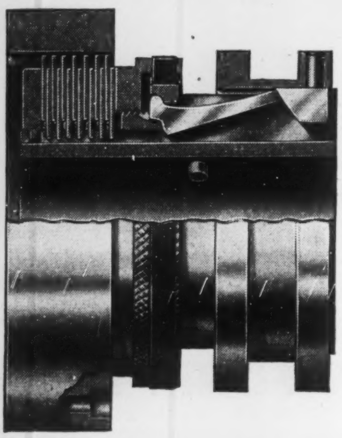
Makers of the famous YALE lines of Locks, Hardware, Door Closers, Hoists and Industrial Trucks.

69 EXHIBITORS AT MACHINE TOOL SHOW WERE MAXITORQ USERS!



MAXITORQ CLUTCHES

were conspicuous "by their presence" in booth after booth . . . smoothly transmitting power on nationally known machines in operation.

This Floating Disc Maxitorq of ours was certainly in good company . . . and it is fast gaining new friends, new original equipment selections for varied types of machinery not on exhibition at the show.

And there are good reasons why . . . points of superiority in design principles, construction and adjustment, that are exclusively Maxitorq.

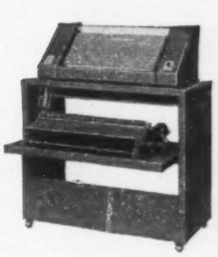
For instance; Separator Springs that "float" the discs apart in neutral to prevent drag, abrasion, heating. Manual adjustment, take-apart, assembly . . . no tools required. Then too, clutches are completely assembled on the body, shipped ready to slip onto a shaft.

There are many other Maxitorq details that machine designers and machinery manufacturers should know, and they are all covered in the new catalog available on request. Write us today for Cat. No. MD 11.

Let's talk
MAXITORQ

THE CARLYLE JOHNSON MACHINE COMPANY
MANCHESTER • CONNECTICUT

ONE SIMPLE MACHINE . . . .



ONE OPERATOR . . .

give you EVERY kind of print you need!

Black line direct process prints—colored line prints—intermediate prints—thin or card-weight prints—photographic prints! You get them all—in seconds—with the Bruning Model 2 BW and Copyflex Continuous Printer. You can reproduce anything typed, printed, illustrated or drawn—right in your own drafting room, engineering department or office—with only one operator!

The Model 2 Printer provides a convenient means of making Bruning BW Direct-Line Prints from any translucent or transparent original material. Prints are made directly from originals—no negative is needed. BW Prints are developed in the Model 153 Developer, combined in a simple stand with the Printer.

Then, at the flick of a switch, the Model 2—a continuous printer not to be confused with "copy-box" methods—exposes Copyflex Photographic Prints. You can have clear reproductions of shaded drawings, photographs, halftones, etc., and reproduce opaque originals either from one or both sides. Copyflex Prints are developed with three trays and a simple drier (readily available).

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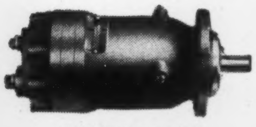
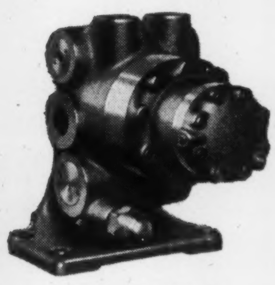
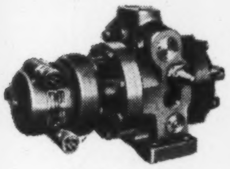
You'll do a Better Job with these . . .



FLUID MOTORS

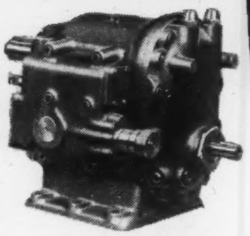


CLAMPING PUMPS

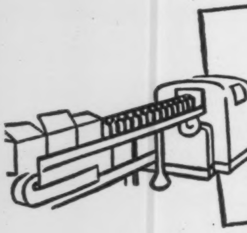


PUMPS

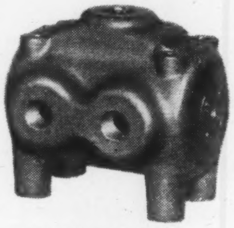
COMPACT UNITS
. . . designed from standard hydraulic elements and used for positioning of blades on road graders, etc.



TRANSMISSIONS

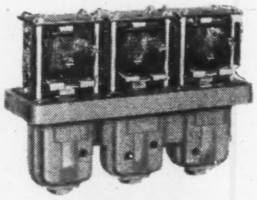


VARIABLE SPEED CONTROL
. . . such as required on packaging machinery where accurate fast control and consistently accurate duplication of movements are a necessity.



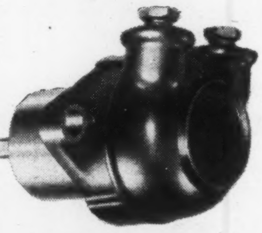
FOUR-WAY VALVES

FAST, SNAPPY ACTION
. . . as needed in materials handling equipment for moving heavy loads quickly and accurately to required heights.



SINGLE AND TRIPLE SOLENOID VALVES

EFFECTIVE SPEED AND FEED CONTROL
. . . as required on machine tools for various movements including consistently accurate clamping pressures.



LUBRICATING PUMPS

Sundstrand Hydraulic Elements Yes, if your designing new equipment or re-designing present models you'll do a better job with these Sundstrand standard hydraulic elements.

You'll do a better designing job because the elements are all time tested and perform efficiently in any required combination.

Many designers have found better solutions to requirements similar to those listed at the left—better hydraulic circuits with less equipment, through the use of these time-tested standard elements and Sundstrand's engineering service.

One of our hydraulic application engineers will be glad to help you with your designs. There is no obligation for this service.

FREE Additional Data
Write for complete literature covering details and specifications of the elements shown above. Ask for bulletin No. M-22.

SUNDSTRAND HYDRAULIC DIVISION

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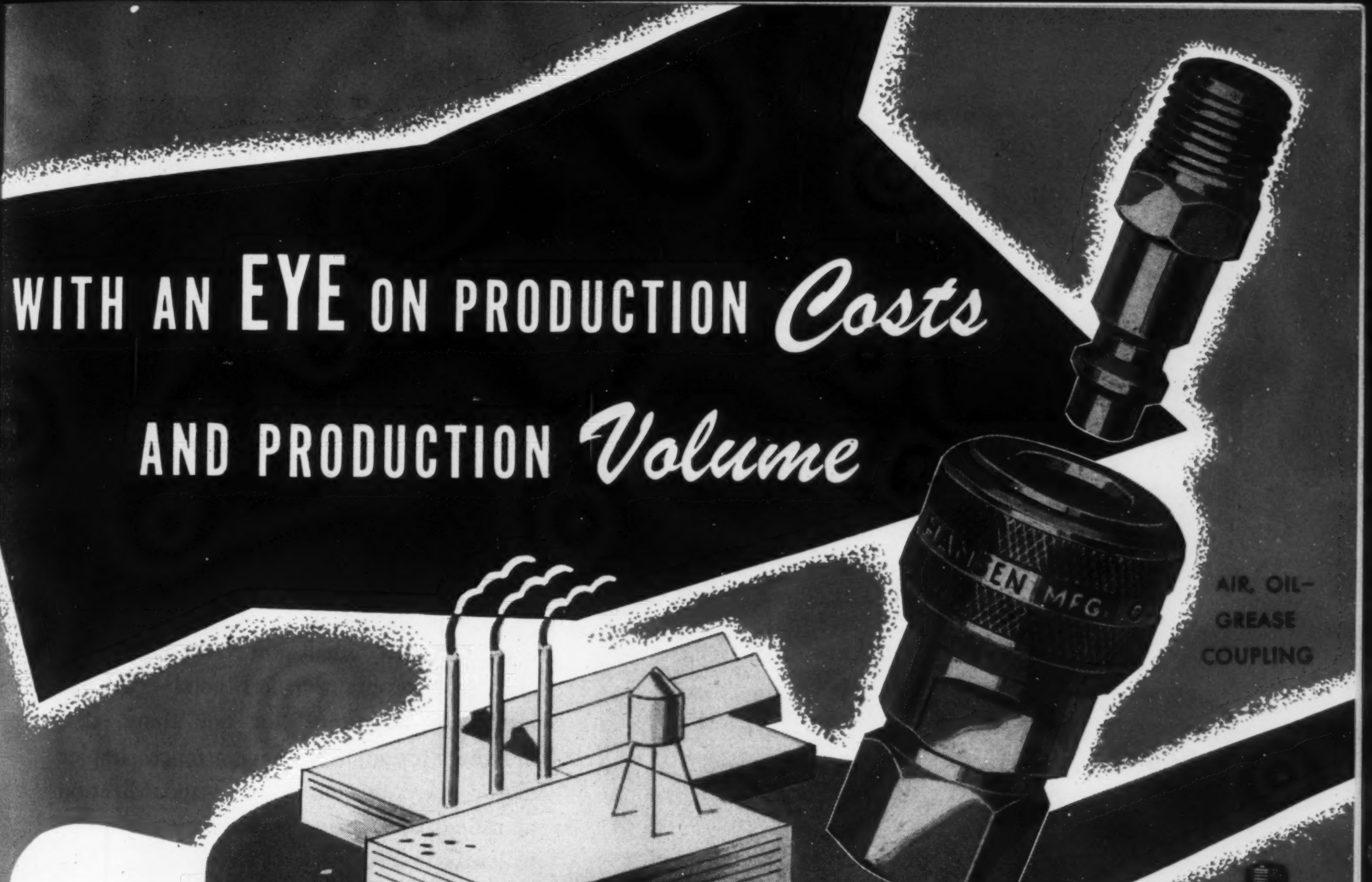
FUEL UNITS • HYDRAULIC PUMPS • TRANSMISSIONS • FLUID MOTORS • VALVES and CONTROLS

WITH AN EYE ON PRODUCTION *Costs* AND PRODUCTION *Volume*



OXYGEN COUPLING

The Hansen Two-Way, Shut-Off Coupling.

HANSEN COUPLINGS

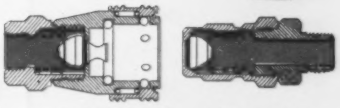
SAVE TIME...CUT COSTS

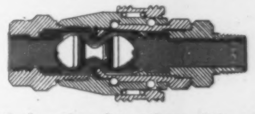
It's the minutes saved on operations repeated many times daily that mount up to substantial savings in time...and money. With Hansen Couplings, connections and change-overs become a matter of seconds with no hold-up of costly operations.

To connect a Hansen coupling, you merely push plug into socket. To disconnect, slide sleeve back with thumb. In both cases, flow is immediately and automatically turned on or off . . . with no time wasted, no losses.

There is a specific Hansen coupling, made for air, oil or grease, for oxygen, and for acetylene. Available in a wide range of standard sizes.

Write for catalog describing full line of Hansen couplings and fittings for industrial use.


Red section shows how rubber washer in valve stem contacts valve seat in both plug and socket, sealing both plug and socket against leakage instantly.


Red section shows flow of liquid or gas around spool section of valve, permitting free flow of liquid or gas through coupling instantly upon connection.

ACETYLENE COUPLING

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THE HANSEN MANUFACTURING CO.

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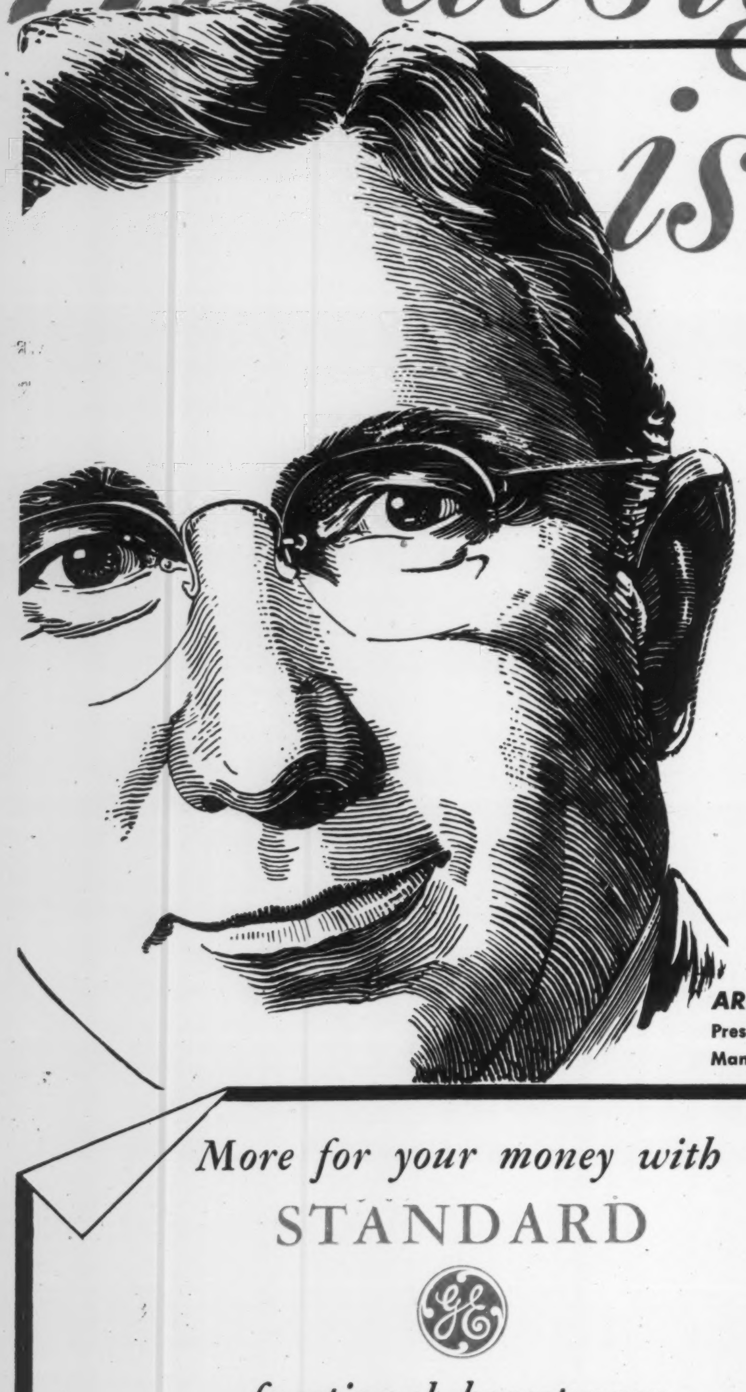
His design job is easier



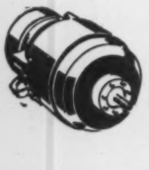
TO A design engineer like Arnold Eckhart, Sr., of the Eckhart Manufacturing Co., the new small-power motor standardization program makes good engineering sense. It means, for one thing, that designers are going to have a much simpler motor selection job. With standardization of ratings and performance, they are going to know *in advance* just what load a motor can safely carry. They are going to have greater assurance that the motors they specify are engineered specifically to give dependable service on the particular type of equipment they design.

ARNOLD ECKHART, SR.,
President and Chief Design Engineer, Eckhart Mfg. Co.,
Manufacturer of Silent Korth Heating Equipment.

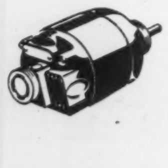
More for your money with STANDARD *fractional horsepower* MOTORS

FOR EXAMPLE General Electric oil burner motors give you the economy of standard design in a motor that is tailor-made for oil-burner service. Meeting the requirements of Underwriters' Laboratories, Inc., these motors give years of quiet, reliable operation. Their trim good looks harmonize with modern burner design.

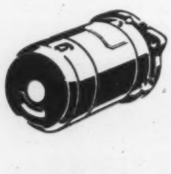
THE NEW STANDARDS to which General Electric fractional horsepower motors are being built were not set by G.E. Nor were they set for the convenience of any other electrical manufacturer. Rather, they are the result of co-operative effort on the part of motor users, your industry associations, and the National Electrical Manufacturers Association. They represent the



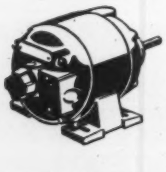
Unit-Bearing Fan



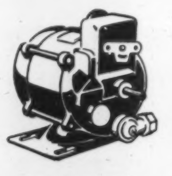
Washing Machine



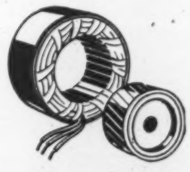
Oil Burner



Machine Tool



Gas Pump



Hermetic Refrigeration

F. V. OWEN,
Director of Purchasing, Tecumseh Products Co.

His delivery worries are less

FRACTIONAL horsepower motor standardization is a "natural" for the purchasing agent. No wonder F. V. Owen, Director of Purchasing, Tecumseh Products Co., says: "I can see how, by sticking to standards, we'll have a better chance of getting off-the-shelf motor deliveries. This will mean fewer purchasing, inventory, and stocking problems. Moreover, standardization will give us wider interchangeability of motors from different manufacturers.

"In the long run, too, you should be able to give us more motors for our money."

best co-ordination of motor design with the current needs of fractional-hp motor users. As the needs of motor users change, moreover, these standards will be changed. They will be modified and modernized to reflect *continuously* the trends in user industries. *This standardization is not static!*—and it is not limiting to the designer. General Electric now produces the 11 groups of definite-purpose motors shown, each specifically engineered to meet the needs of a certain application, and 11 types of general purpose motors. (More groups will be added.) In each group you will find a full range of ratings—a total of more than 1600 *standard* motors to choose from.

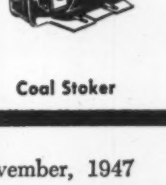
NEW BULLETIN DESCRIBES STANDARDS

To help you determine just how the new NEMA standards will affect your motor selection problems, we have prepared a brief, but concise bulletin which tells what the standards are and how they are applied. Ask your local G-E office for bulletin GES-3565—and for data on any of the motors listed below—or write *Apparatus Dept., General Electric Co., Schenectady 5, N. Y.*

GENERAL ELECTRIC

700-81

Belted Fan

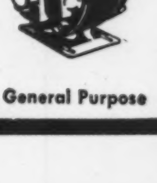


Coal Stoker

Jet Pump

Shaft-Mounted Fan

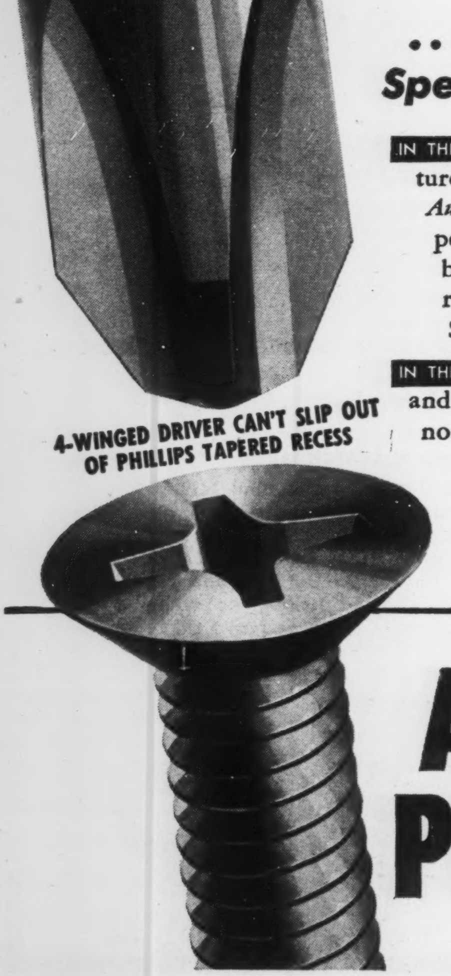
Sump Pump



General Purpose

"It Isn't Santa Claus, Kiddies"—
but Brand and Baby both Benefit

. . . when AMERICAN PHILLIPS SCREWS
Speed Assembly—Make Sturdier, Smarter TOYS


4-WINGED DRIVER CAN'T SLIP OUT
OF PHILLIPS TAPERED RECESS

IN THE PLANT — It's a Xmas Bonus in time-savings (up to 50%) for toy manufacturers who cash in on the super fastening speed of American Phillips Screws. *Automatically* straight to drive, non-slipping, they can't harm product or personnel. Screws can't be fumbled, time can't be lost, heads can't be burred. Whether you make miniature trains or real ones, sofas or stoves, radios or refrigerators—output and savings go *up* when American Phillips Screws go *in!*

IN THE SHOWROOM — Toys (or whatever you make) have both a "can take it" and "take me with you" look! For children and grown-ups, there's the safety, non-snagging feature. American Phillips Screws join your sales promotion staff, make your product sturdy, eye and buy-appealing. And more and more buyers know it!

AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND
***Chicago 11:* 589 E. Illinois St.** ***Detroit 2:* 502 Stephenson Building**

AMERICAN PHILLIPS *Screws*

ALL TYPES
ALL METALS: Steel, Brass, Bronze, Stainless Steel, Aluminum, Monel, Everdur (silicon bronze)

What does your product need to make it easier to sell?

Does it need resistance to corrosion?

Tanks and ductwork, metal cabinets, refrigerating, ventilating and air conditioning equipment, etc., that are prone to rust can be built to last longer by using U·S·S Copper Steel. Costing only 5% more than plain steel, it offers double the resistance to atmospheric corrosion. When even greater resistance to atmospheric corrosion is needed, U·S·S COR-TEN will provide it at reasonable cost. And where corrosive conditions are especially severe, U·S·S Stainless Steel will give resistance unsurpassed by any other commercial metal.

Does it need greater ruggedness?

In heavy duty equipment like this, U·S·S High Strength Steels —such as U·S·S COR-TEN and U·S·S MAN-TEN—used in structural members and body plates will provide stamina with the least increase in cost. In gears, axles and bearings where stress is concentrated, U·S·S Carilloy Steels will provide maximum endurance with minimum weight. No other manufacturer of alloy steels can offer you such a complete range of form, dimension and treatment.

Must it be strong yet light in weight?

Used in buses, trolley coaches, trucks and trailers, in freight and passenger cars, and in fact in all kinds of mobile equipment, U·S·S COR-TEN—the pioneer low-alloy, high-strength steel—will trim off hundreds of pounds of dead weight, yet at the same time will provide increased structural strength and ruggedness. U·S·S COR-TEN costs so little more than plain steel and fabricates so readily that these benefits can be obtained at little or no increase in cost. When the ultimate in weight reduction is desired, and its higher cost is justified, U·S·S Stainless Steel will permit even more drastic savings in weight.

Are good looks important?

In household equipment of all kinds—refrigerators, stoves, washing machines, etc.—porcelain enamel on steel adds beauty, cleanliness and the ability to stay new that women appreciate. Its resistance to chemical action, to moisture, and heat are added advantages that recommend its use in food plant equipment, in bakery and dairy apparatus, and for shower and toilet partitions and wall panels. U·S·S VITRENAMEL is an improved steel base for porcelain enameling that insures maximum life and permanent good looks. In knives, table tops, kitchen sinks, in pots and pans and electrical appliances U·S·S Stainless Steel combines irresistible eye-appeal with unmatched durability.

9 times out of 10 STEEL will do it better

CARNEGIE-ILLINOIS STEEL CORPORATION
Pittsburgh and Chicago
Columbia Steel Company, San Francisco, *Pacific Coast Distributors*
United States Steel Supply Company, Chicago, *Warehouse Distributors*
United States Steel Export Company, New York

USS STEEL UNITED STATES STEEL

UNITED STATES STEEL

NATIONAL OIL SEAL LOGBOOK

15 WAYS
TO AVOID LEAKAGE AROUND AN OIL SEAL

Most leakages around oil seals are the result of improper installation. 15 common causes of such leakage are listed here, along with suggestions for correction. This chart contains valuable information for designers and manufacturers. It tells how to prevent leaks. And it gives trouble-shooters help when "leakers" do occur.*

CAUSE	CORRECTION	CAUSE	CORRECTION
Rapid and extreme shaft wear at point of sealing flange contact due to soft steel in shaft.	Shaft hardness must be to a minimum of 30 Rockwell C scale.	Paint lodged between sealing flange and shaft during painting process of entire unit.	Seal should be masked during painting process.
Shaft not polished at point of contact of sealing flange.	Shaft should have a finish of 20 rms (Maximum) at point of flange contact, for proper fluid retention and long life at high speeds.	Vent plug clogged during painting process causing built-up pressure.	Mask vent plug before painting.
Shaft finish, on close examination, showed riding spirals working outwardly.	(1) Grind shaft so that spiral works inwardly toward fluid; or (2) polish shaft with crocus cloth at point of flange contact until spiral is removed.	Sealing member scratched by sharp edges on chamfer, during assembly.	Chamfer must have a radius and be free of sharp edges and nicks. See Installation Instructions, Catalog No. 101.
Shaft nicked and scratched by contact with other parts during transportation from shaft-finishing operation to point of assembly.	Shaft finish must be protected to the point of assembly of seal.	Scratched and damaged seals due to contact with other parts when in lug boxes.	Oil seal, particularly the sealing member, should be carefully protected at all times.
Oil leakage past O.D. of seal because seal improperly installed in cocked position.	Proper installation tools should be used. See Installation Instructions, Catalog No. 101.	Shaft runout excessive.	For low speeds, shaft runout should not exceed .008". For higher speeds, it should not exceed .004".
Seal dented and distorted during installation.	Proper installation tools should be used. See Installation Instructions, Catalog No. 101.	Excessive stretch of the sealing member due to use of oversize shaft assembly tool.	The O.D. of the shaft assembly tool should not be over 1/32" larger than shaft diameter.
Leakage at O.D. of seal due to housing bore being out of round.	Housing bore should be concentric within .001". Some users of oil seals coat the O.D. with a special cement to overcome possible slight eccentricity or roughness of housing.	Oil seal distorted due to housing being too small for the O.D. of seal.	Housing bore should be within ±.001" of housing bore recommended for the particular seal shown in this catalog.
		Apparent oil leakage due to application of excessive grease on flange before assembly.	Only a small amount of lubricant need be applied on the flange when assembled. See instructions, Catalog No. 101.

NOTICE... During following months, the National Oil Seal Logbook will appear regularly on these pages. It will contain much factual information about oil seals—special seals for special jobs, installation precautions and techniques, tips on trouble-shooting.

We suggest you clip and save these pages as they appear. You'll find they form a comprehensive notebook of oil seal information.

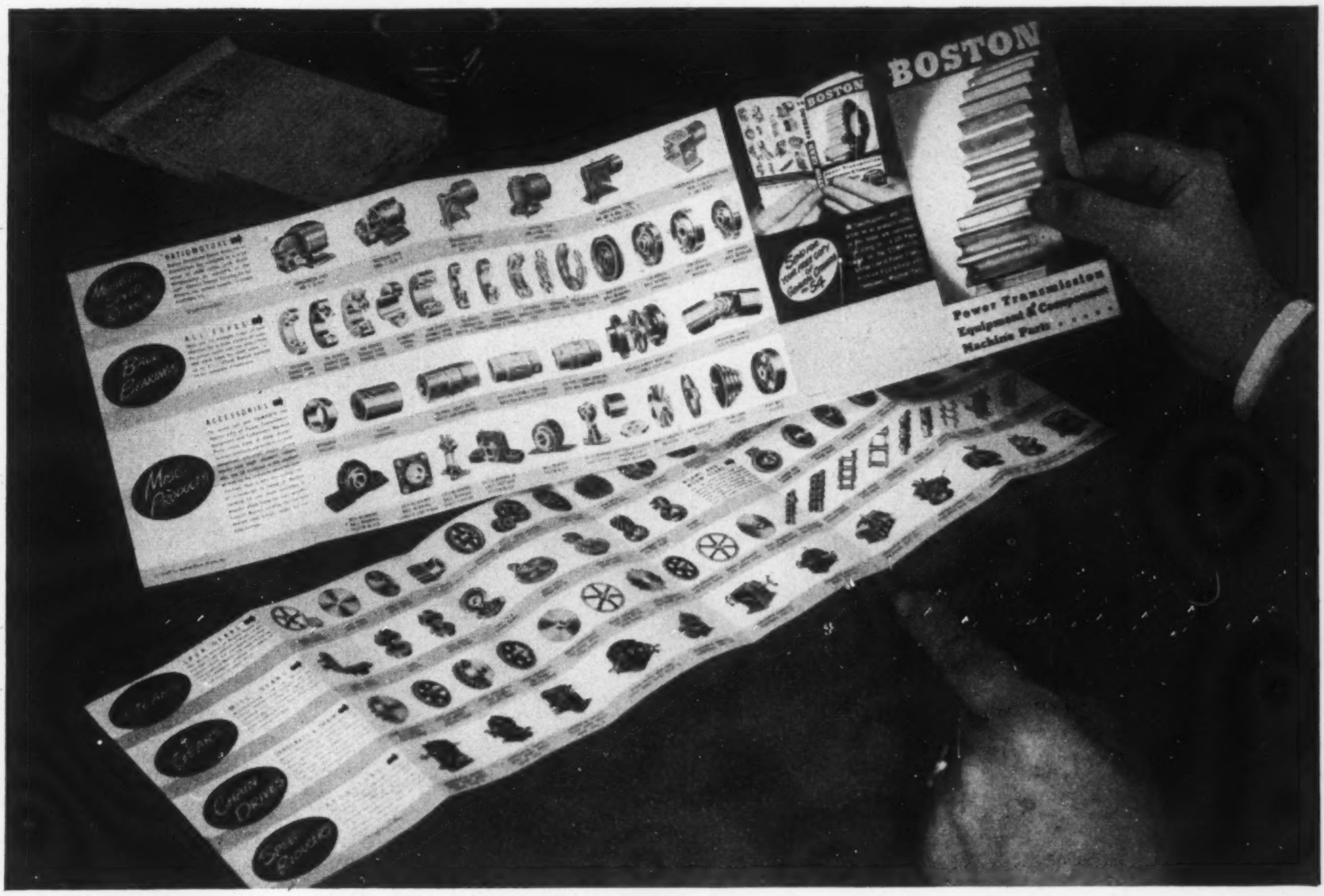
NATIONAL MOTOR BEARING CO., INC.
GENERAL OFFICES: Redwood City, California
PLANTS: Redwood City and Los Angeles, California; Van Wert, Ohio

NATIONAL
OIL AND FLUID SEALS
®

* Information on this page reprinted from National Oil Seal Catalog No. 101

One of the most complete lines I've seen!

The BOSTON line of power transmission equipment and component machine parts gives you one of the widest selections of stock products for the mechanical transmission of power. Consisting of four main divisions — GEARS — SPEED REDUCERS — CHAIN and SPROCKETS — and ALLIED ACCESSORIES — the complete BOSTON line has 101 individual groups of products available in over 4000 stock sizes. Sixty-two distributors carry large stocks of BOSTON Products. Send for your copy of New Folder No. 2-47 and complete list of stocking distributors.



101 SELECT FROM 101 INDIVIDUAL GROUPS OF PRODUCTS

There are 101 groups of products in the BOSTON line — from various types of gears, speed reduction units and chain drives to couplings, pillow blocks, universal joints, ball bearings, pulleys, etc. Select your requirements from over 4000 stock sizes.

62 ORDER FROM 62 DISTRIBUTORS "COAST TO COAST"

For your convenience 62 distributors carrying stocks of BOSTON Products are located throughout the United States and Canada. Simply order BOSTON Products by catalog number and buy from your nearest distributor.

BOSTON GEAR WORKS, INC., NORTH QUINCY 71, MASS.

Please send me .... copies of your New Folder No. 2-47, illustrating your 101 Groups of Products. Also send me your complete list of 62 stocking distributors:

BOSTON
Power Transmission
Equipment & Component
Machine Parts

NAME______________________________

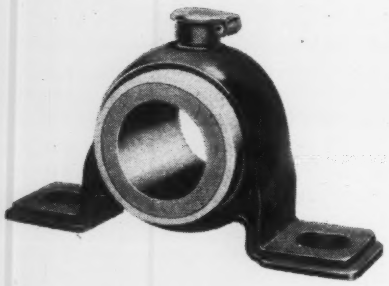
COMPANY______________________________

STREET______________________________

CITY_______________ZONE____STATE________

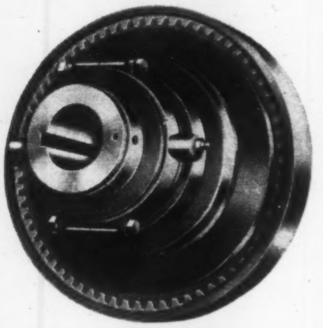
BOSTON GEAR WORKS INC.

NORTH QUINCY 71, MASS.



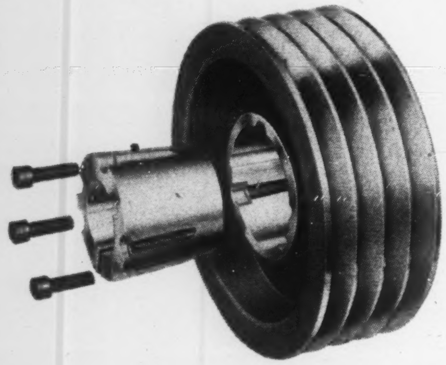
This is the BRONZOIL Bearing. Developed by Dodge for fan and blower service. A new and better transmission appliance.

U. S. Patent No. 1,931,055



This is the ROLLING GRIP Clutch. Developed by Dodge. No toggles. A new and better transmission appliance.

U. S. Patent No. 2,397,414



This is the TAPER-LOCK Sheave. Developed by Dodge. No flange. No collar. A new and better transmission appliance.

U. S. Patent No. 2,402,743

This is the Dodge Transmissioneer—who will tell you about new ways of transmitting power mechanically.

DODGE

of Mishawaka, Ind.

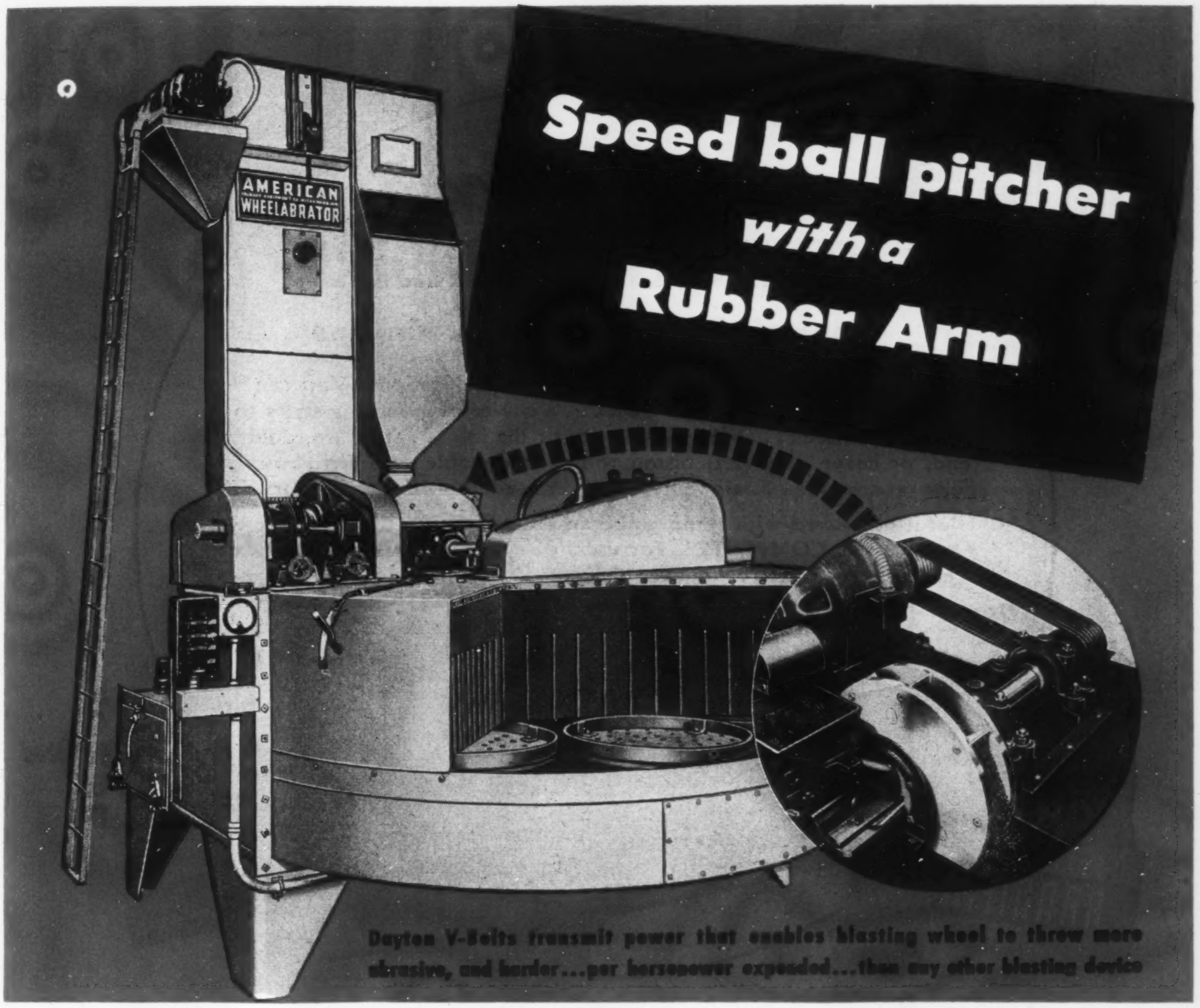
New equipment which helps cut costs, improve machine performance, increase production is offered to you by Dodge of Mishawaka. For detailed information about power transmission units to meet specific needs in your plant, or on your product, call the Transmissioneer, your local Dodge distributor. Look for his name in the classified telephone directory under "Power Transmission Equipment." A talk with him will prove profitable to you.

DODGE MANUFACTURING CORP., MISHAWAKA, IND.

Copyright, 1947, Dodge Mfg. Corp.

NAME PLATES

FOR YOUR NAME PLATE REQUIREMENTS, WRITE OUR SUBSIDIARY,
ETCHING COMPANY OF AMERICA, 1520 MONTANA STREET, CHICAGO 14, ILLINOIS



Speed ball pitcher *with a* Rubber Arm

Dayton V-Belts transmit power that enables blasting wheel to throw more abrasive, and harder...per horsepower expended...than any other blasting device

The need for transmitting great horsepower in a small space was the problem facing the industrial designer of an abrasive blaster. And a Dayton V-Belt Drive solved it.

This is another outstanding example of the flexibility of Dayton V-Belt Drives. And the ability of Dayton V-Belts to perform in excess of standard requirements under all operating conditions . . . unaffected by dust, oil, heat, liquids . . . is another of the many reasons why more industrial designers consistently specify Daytons for original equipment.

No matter what type machine you design, or what size it is, Dayton V-Belts will transmit power to it more efficiently, more economically.

Remember, a Dayton Power Transmission Specialist is always ready to help you . . .

DAYTON RUBBER • DAYTON, OHIO

NOW! *Rayon Cords

PROVIDE DAYTON V-BELTS WITH

1. Minimum Stretch 2. Greater Flex Strength
3. Longer V-Belt Life

* Rayon cords are *specially processed* by Dayton for use in V-Belts to provide the most efficient and economical power transmission service for your machine needs. For the complete story write for booklet A-469.

POWER
Dayton
V-BELT DRIVES

Dayton Rubber

THE MARK OF TECHNICAL EXCELLENCE IN NATURAL AND SYNTHETIC RUBBER

THE WORLD'S LARGEST MANUFACTURER OF V-BELTS

HANNIFIN

Another "SPECIAL" HYDRAULIC CYLINDER!

—out of the Standard Hannifin Line

It's *special* because it's built to YOUR specifications! You can have any length stroke you want . . . a choice of mounting styles to meet your needs . . . bore diameter to fit the job . . . standard, double end, or heavy duty (2:1) piston rod . . . adjustable cushions . . . inlet ports on any side . . . air vents wherever needed — *all "special" for YOU.*

But it's *standard* with Hannifin because the Hannifin line of hydraulic cylinders is COMPLETE! For users of cylinders, this means lower engineering costs . . . quicker delivery . . . completely interchangeable parts . . . better design . . . superior performance. It pays to specify HANNIFIN!

Model JN
One of 11 different mounting styles.

HONED *Tru Bored*

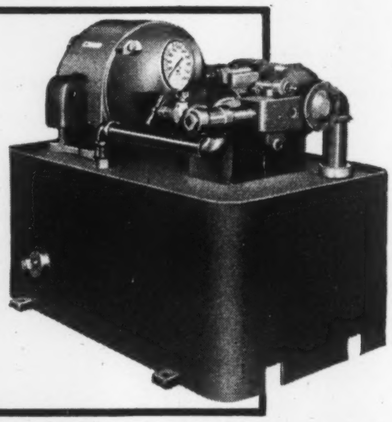
BULLETIN 110
HANNIFIN
Double-Acting
HYDRAULIC
CYLINDERS
HANNIFIN CORPORATION

EVERY DESIGN ENGINEER WILL WANT A COPY OF THIS NEW BULLETIN.

It's easy to get the right answer for even the most special jobs when you use Hannifin's new handbook on hydraulic cylinders. 52 pages of helpful specification and engineering data, complete with diagrams and dimensions. Ask for Bulletin 110-M.

HANNIFIN HYDRAULIC POWER UNIT

Here is an improved hydraulic pressure generator offered by Hannifin in a broad range of sizes. Designed and built for heavy duty service. Capacities to 100 g.p.m. or larger. Choice of pump types—single, double, and combination styles. We will be glad to help you develop circuits and plan controls. See your local Hannifin representative or write.



HANNIFIN

Nationwide Sales and Service

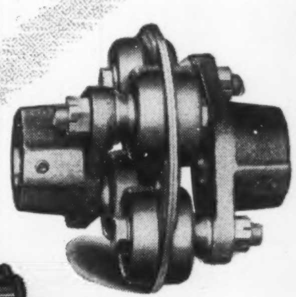
HANNIFIN CORPORATION

1101 So. Kilbourn Ave., Chicago 24, Ill.

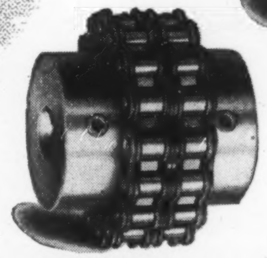
AIR CYLINDERS • HYDRAULIC CYLINDERS • HYDRAULIC PRESSES
PNEUMATIC PRESSES • HYDRAULIC RIVETERS • AIR CONTROL VALVES

GOOD CONNECTIONS!

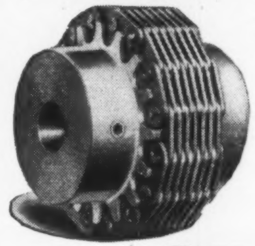
can be made with MORSE COUPLINGS!



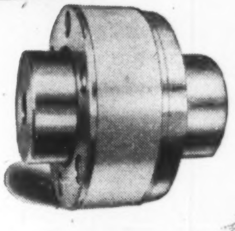
MORFLEX COUPLINGS—Torsionally resilient. Quiet in operation, no metal-to-metal contact. Requires no lubrication or maintenance.



ROLLER CHAIN COUPLINGS—Morse double width roller chain around two sprockets. Rugged flexibility, all-steel design. Compact and economical.



SILENT CHAIN COUPLINGS—Morse silent chain around two sprockets. Easy to connect and disconnect. Compensate for both parallel and offset misalignment.



MORFLEX RADIAL COUPLINGS—Completely machined, perfectly balanced. For large torque capacity. Compensate for misalignment, cushion peak-loads.

IMPROVE YOUR CONNECTIONS! For every application there is a Morse coupling that is ideally suited because of the wide range in types, capacities and prices. Morse couplings are carried in stock for immediate delivery by industrial distributors throughout the country. Morse engineers, backed by years of experience, can assist you. Consult our Coupling Division. MORSE CHAIN COMPANY • Detroit 8, Michigan.

MORSE MECHANICAL POWER TRANSMISSION PRODUCTS

A PRODUCT OF B-W BORG-WARNER

THESE NO. 20V **WHS** VERTICAL *Differential* SPEED REDUCERS

WORK 24 HOURS A DAY

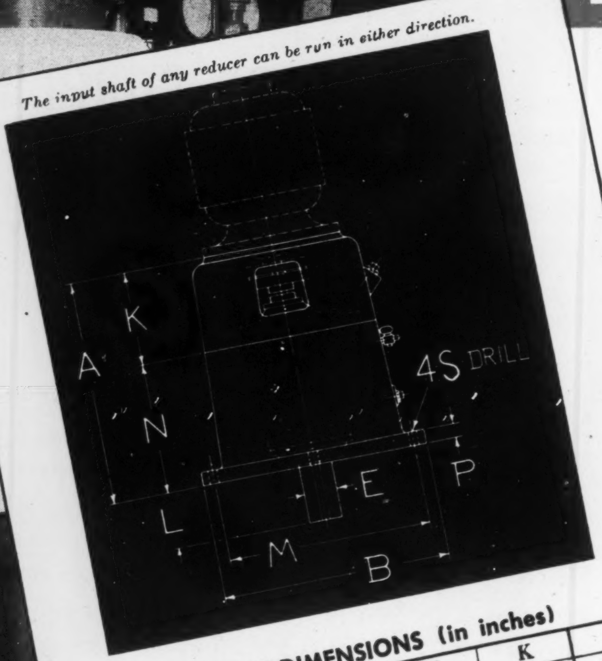
Driving Vertical Mixers for Vegetable Oil Refining

This DeLaval Separator Company installation . . . in Cudahy Packing Company's Leewood Refinery at Memphis, Tenn. . . . incorporates a battery of WHS Vertical Differential Reducers, each reducer with a ratio of 3.09:1 and powered by a 5 H.P. motor. They were selected for their

DEPENDABILITY

as well as for their compactness, ease of installation and simplicity of mounting. The slow speed shafts are directly coupled to the mixers with a gear flexible coupling.

The input shaft of any reducer can be run in either direction.

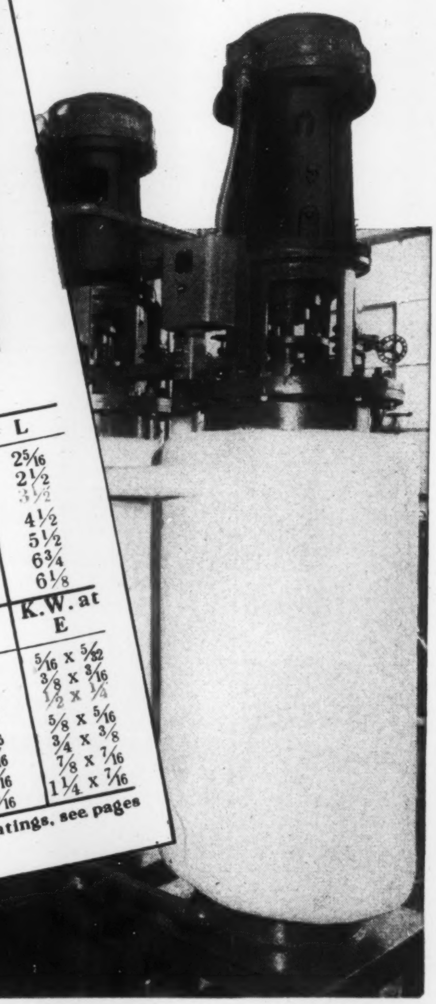


GENERAL DIMENSIONS (in inches)

Unit	A	B	E	K	L
7V	12 15/16	11 7/8	1 1/4	5 15/16	2 5/16
10V	14	13	1 1/2	6 3/4	2 1/2
20V	16 11/16	15 3/8	2 1/16	7 3/4	3 1/2
30V	18 1/4	18 1/8	2 5/8	7 5/8	4 1/2
40V	21	21 1/2	3 3/16	8 1/4	5 1/2
50V	24 5/16	26 1/8	4	9 1/4	6 3/4
60V	32 7/8	39	5	14 1/2	6 1/8

Unit	M	N	P	S	K.W. at E
7V	10 5/8	7	3/4	9/16	5/16 x 5/32
10V	11 1/2	7 1/4	7/8	9/16	3/8 x 3/16
20V	13 3/8	8 5/16	1 1/8	9/16	1/2 x 1/4
30V	16 1/4	10 15/8	1 1/8	11/16	5/8 x 5/16
40V	19 1/2	12 3/4	1 1/4	11/16	3/4 x 3/8
50V	23 3/4	15 1/16	1 1/2	13/16	7/8 x 7/16
60V	33 3/4	18 3/8	2	1 5/16	1 1/4 x 7/16

NOTE: For Horsepower, Torque and Chain Pull Ratings, see pages 82-95.



WHS PATENTED Differential Helical Gear Speed Reducers provide any ratio of reduction from about 3 or 4 up to many thousands to 1 . . . in a single stage and in the same housing.

They are fully illustrated and described in our pocket-size Catalog No. 147. Send for a copy. It also includes valuable engineering data.

MEMBER OF AGMA

WINFIELD H. SMITH CORPORATION
16 ELTON STREET . . . SPRINGVILLE . . . ERIE COUNTY . . . NEW YORK

SKILL MAY BE BOUGHT, BUT NOT THIS EXPERIENCE

To lead an industry is no small undertaking, but it brings satisfaction to both the leader and the user of his product.

It is not remarkable that roller chains and sprockets were pioneered by Diamond; the remarkable thing is that Diamond never added another product. In the entire 57 years since Diamond began, all thinking, all resources, have been bent to one purpose—better and better Diamond Chain and Sprockets. We think this is not too much effort to spend in perfecting one product, for never once has it appeared that the final refinement was made.

The mechanical skill to make products like Diamond Chain may be bought, at a price, but the Diamond reservoir of manufacturing and application experience is exclusively a Diamond property. The result of this skill and experience is a drive of unsurpassed merit—an improvement on the machines where it is used, and a strong asset in the sale of those machines.

Recommendations by Diamond Engineering Staff may point the way to improve the performance and output of your machinery.... DIAMOND CHAIN COMPANY, Inc., Dept. 435 402 Kentucky Ave., Indianapolis 7, Indiana. *Offices and Distributors in All Principal Cities.*

Drive Data Catalog 617 mailed on request

DIAMOND ROLLER CHAINS

You're OK with P-K for...

GROUND THREAD
UNIFORMITY
IN SOCKET SET SCREWS

A new standard of quality and *uniformity* has been pioneered by P-K in the quantity production of Cold-forged *Ground Thread* Socket Set Screws. Ground on hardened blanks, threads are mirror-smooth, assure a dependable Class 3 Fit. Consistently uniform and free from nicks, burrs and hardening scale, they have none of the imperfections common to cut threads.

Compare! *Ask for Samples.* See why P-K Ground Thread Socket Set Screws are different from ordinary set screws as night and day. You'll agree your products will benefit — assembly - wise and sales - wise! Parker-Kalon Corp., 200 Varick St., New York 14, N. Y.

AVAILABLE FOR PROMPT DELIVERY

GOOD JUDGMENT CALLS FOR

PARKER-KALON

WHEN GOOD DESIGN CALLS FOR

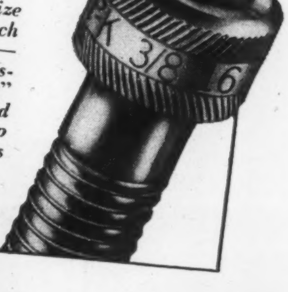
SOCKET SCREWS

SOLD ONLY BY ACCREDITED DISTRIBUTORS

SIZE-MARKED • GEAR GRIP* SOCKET HEAD CAP SCREWS

Another P-K First

Gives you size and thread pitch at a glance — eliminates guessing or "miking" — saves time and errors. Gear Grip prevents slips and fumbles.



*U. S. Pat. No. 126,409

Saving on lubricant alone is $1200 a year with Farval

A COAL company faced a serious lubrication problem in one of its tipples. It seemed impossible to find a lubricant that would stay in the crusher, shaker screen and washer bearings, especially in the eccentrics, between visits of the oiler. As a last resort they were using a special, very heavy grease costing 13½¢ a pound, and still the oiler had to go around to renew it every hour. As the tipple was operating 24 hours a day, 6 days a week, the cost of grease alone was running more than $200 a month.

Then they decided to try a Farval Automatic Centralized System of Lubrication to serve the 295 bearings on the tipple. With Farval they could deliver an accurately measured quantity of grease to each bearing regularly and as often as necessary. Experience soon demonstrated a 30-minute interval to be best. Not only did Farval reduce the amount of lubricant consumed but it was also possible to switch to a standard grease, resulting in a saving of 50% on lubricant cost alone.

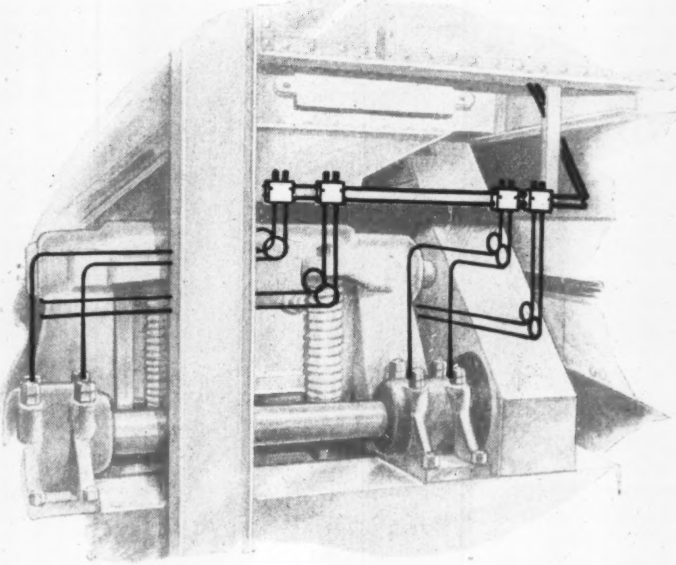
Actually, the saving on lubricant was small compared to the saving in labor, the reduction in bearing replacement expense, and the elimination of frequent shutdowns and interruptions to production experienced previously, due to faulty lubrication.

Farval Centralized Lubricating Systems have been serving the coal industry for more than 17 years. In preparation plants, Farval lubricates Feeders, Crushers, Conveyors, Shakers, Vibrating Screens, Elevators, Washers, Jigs, Dryers, Mixers, Loading Booms and Drives.

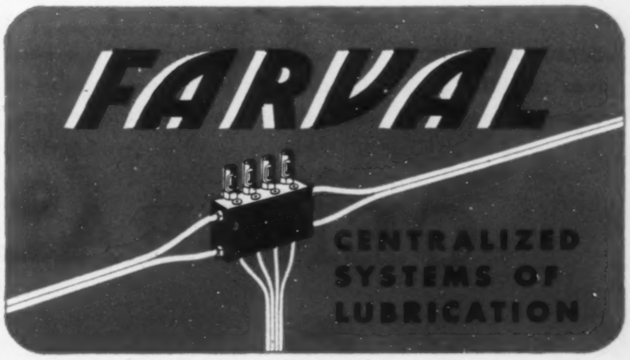
Farval is the Dualine System of Centralized Lubrication, with the Positive Piston Displacement Valve. This valve has but two moving parts and is fully adjustable, with a Tell-tale indicator at each bearing to show the job is done.

Write for Bulletin 25 for a full description of Farval. The Farval Corporation, 3265 East 80th Street, Cleveland 4, Ohio.

Affiliate of The Cleveland Worm & Gear Company, Industrial Worm Gearing. In Canada: Peacock Brothers Limited.

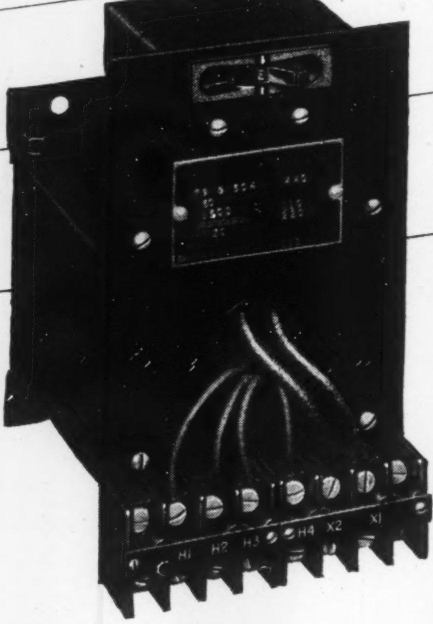


FARVAL—*Studies in Centralized Lubrication*
No. 97



Designer's

The Machine Tool Transformer YOU asked us to Build



Yes, here at last is a line of transformers designed specifically for machine tool use. We didn't guess at what you wanted in such transformers. We asked machine-tool designers throughout the country. This new line of G-E machine tool transformers is the result. It incorporates every practical suggestion your profession had to offer.

A COMPLETE RANGE OF RATINGS. Ten ratings, from .075 to 3 kva, 60 cycles, 220/440 volts will meet most of your domestic requirements. For foreign and unusual domestic applications, the line includes an all-purpose group of transformers rated 50/60 cycles, with eight primary taps from 208 to 550 volts. Also available are 25-cycle units in four standard sizes from .150 to .5 kva, with primary taps for 220, 440 and 550 volts.

HARMONIOUS APPEARANCE. The trim good looks of these transformers harmonizes with other modern components to make neat, functional control-panel arrangements.

VOLTAGE REGULATION. Regulation characteristics have been given careful attention to assure satisfactory operation of motor-starting relays which cause heavy momentary overloads. Hence, there is no need for use of greatly oversized transformers to handle momentary surges. To help you select the right transformer, see the complete regulation data in our new machine tool transformer bulletin.

OVERLOAD PROTECTION. These transformers have a built-in overload protector, with time-delay action, to prevent damage under sustained overload or accidental short circuit.

EASY TO INSTALL. With the diagrammatic nameplate, errors in connection are avoided. Only a screw driver is needed to make solid connections on the front-mounted terminal board. Molded-plastic terminal barriers prevent accidental shorts. These new transformers save space, save installation time, and reduce inventories. For full information ask for Bulletin GEA-4887.

GENERAL ELECTRIC

Digest

TIMELY HIGHLIGHTS ON PRODUCTS

SOLENOIDS ARE BACK

This General Electric a-c solenoid is *not* new, but it is currently being built in increasing quantities . . . shipments are short enough now so that you can safely include it in your new designs. The performance record of these units is responsible for their popularity among machine designers.

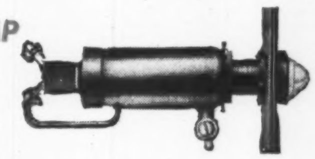
Any straight-line push or pull, from 0.9 to 97 pounds, is easy for this industrial solenoid. It may be operated remotely from a push-button station, or automatically by limit switches, pressure switches, float switches, or other pilot circuit devices. Check Bulletin GEA-2080 on coupon.

VERSATILE HAND "TACH"

Here's a new hand-held electric tachometer for checking performance on your machines. It measures rotational speed in three ranges from 100 to 10,000 rpm; and linear speed in six ranges from 10 to 10,000 fpm. With accessories, you can measure speeds from 10 to 100,000 rpm.

Accuracy of ± 1 per cent is unaffected by magnetic fields, machine vibration, or temperature. Scale is large and easy to read—with no crowding on any range. Speed ranges can be changed while spindle is rotating—and instrument can not be damaged by overspeeding. Requires only $\frac{1}{4}$ ounce-inch driving torque. Measures both clockwise and counterclockwise rotation. See Bulletin GEA-4895.

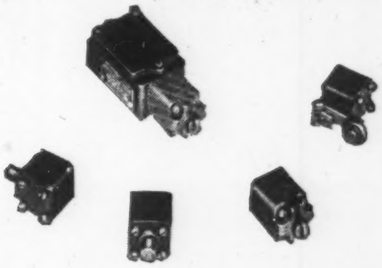
NEW INDICATING LAMP



The new Type ET-5 indicating lamp is designed to harmonize with modern panel instruments and to give high visibility from any angle. Caps are available in six fast colors. Series resistor limits current in lamp circuit, eliminating need for low current fuses. Two types: for panels up to $\frac{1}{4}$ inch thick and for panels up to 2 inches thick. Check Bulletin GEA-3643.

For positive snap action:

TYPE K-1 LIMIT SWITCH



You can specify any one of four different heads—roller-lever, side push-rod, top push-rod, roller push-rod—on the General Electric Type K-1 snap action limit switch. And you have a choice of four head positions . . . that's real versatility. Snap action means sure, positive operation; contacts always open at the same point.

Cutting fluids and oil will not damage these switches, thanks to oilproof construction. They are physically small (approx. $1\frac{1}{2}$x$3\frac{1}{2}$x$1\frac{3}{8}$ inches), yet handle up to 10 amps at 110/220 volts a-c. Bulletin GEA-4644.

Type J-1 Snap-action Limit Switch, big brother to the Type K-1, is rated 10 amps at 110 volts and will interrupt up to 30 amps. These general-purpose limit switches have gained wide acceptance in industry—are noted for their reliability, ease of installation and versatility of application. Available now! Bulletin GEA-4643.

GENERAL ELECTRIC COMPANY
Apparatus Dept., Section F 668-57, Schenectady 5, N. Y.

Please send me the following bulletins:

☐ GEA-4887—Machine-tool Transformers
☐ GEA-3643—Type ET-5 Indicating Lamp
☐ GEA-4895—New Hand Tachometer
☐ GEA-2080—Solenoids
☐ GEA-4644—K-1 Limit Switch
☐ GEA-4643—J-1 Limit Switch

CONSULT YOUR SWEET'S! You'll find "everything electric" for machinery manufacturers in the General Electric section.

NAME...
COMPANY...
STREET...
CITY..................................STATE.......................

How to do MORE *work... with* LESS *effort!*

Hanna Cylinder
Hanna Cylinder

... use Hanna *air and hydraulic* Cylinders

In countless industrial applications, the productive capacity of both men and machines is limited by the capacity of human muscles. Hanna pneumatic and hydraulic muscles provide the economical—and tireless—answer to this problem. Wherever a controlled push, pull, lift, press or clamp is required on any type of equipment, Hanna cylinder power will do the job quickly, smoothly, accurately. Find out more about how these muscles can work for you by sending for the catalogs described at the right.

Hanna Hydraulic Cylinders

● Catalog 233 gives full technical and operating data on Hanna Hydraulic Cylinders.

Hanna Cylinders

● Catalog 234 gives the same information on Hanna Air Cylinders.

Hanna Engineering Works

HYDRAULIC AND PNEUMATIC EQUIPMENT . . . CYLINDERS . . . VALVES . . . RIVETERS

1765 Elston Avenue, Chicago 22, Illinois

Wichita City Lil

a toolmaker learns a lot about Brass

In his early training, he soon learns that brass is a *machinable* metal . . . that cutting tools take to it like a duck to water.

He learns, too, that brass is a *workable* metal . . . that it can be spun, stamped, pressed, coined, upset or drawn with consistent accuracy and uniformity.

And, in the years that follow, he becomes aware of yet another asset of this easy-to-use metal . . . its *dependability*. For products made of brass are strong, durable and rustless . . . economical . . . high in quality.

The American Brass Company is Industry's largest supplier of brass and other copper alloys in all standard compositions and in practically all commercial shapes. Its facilities for serving you include 10 Manufacturing Plants, 5 Warehouses, 27 District Offices and a network of Distributors throughout the Nation.

next page, please . . .

THE AMERICAN BRASS COMPANY
General Offices: Waterbury 88, Connecticut

ANACONDA
from mine to consumer

Anaconda Copper & Copper Alloys

Brass Serves Best

IN PRODUCTION
IN PERFORMANCE

The forming, perforating, threading, machining, plating and polishing operations necessary to fabricate the Basket Sink Strainer Assembly, shown here, could be performed effectively and efficiently on only *one* metal, a *brass alloy*. Equally important, this product must give years of satisfactory performance in corrosive service—and sell at a competitive price.

To obtain these essential qualities, the Frost Company of Kenosha, Wis., depends on Anaconda Brass, furnished to unvarying and precise specifications for composition, grain size, temper and finish. The Technical Department of The American Brass Company is ready to confer with you on any metal problem involving a combination of required properties.

ANACONDA
from mine to consumer

Anaconda

COPPER and BRASS

THE AMERICAN BRASS COMPANY
General Offices: Waterbury 88, Connecticut
Subsidiary of Anaconda Copper Mining Company
In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

47114

How Reliance V★S can help *you* meet the greatest challenge industry has ever faced

WAGES go up and up, along with materials and other manufacturing costs. But to keep America prosperous, prices cannot be permitted to spiral to the point where large numbers of consumers are forced out of the market. How to prevent this presents the greatest challenge industry has ever faced.

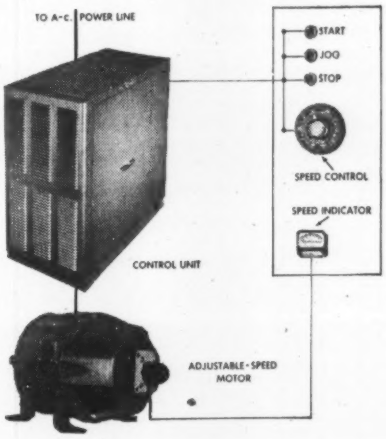
One sound answer is increased production through the use of more efficient machinery and methods. And this is where Reliance V★S can help you. *We have yet to find the industry where the V★S Drive cannot improve the quantity and quality of output, while lowering costs.*

A Reliance Application Engineer will survey your operations, then show you where and how you can benefit most through use of V★S—*the All-electric, Adjustable-speed Drive, operating from A-c. Circuits.* Just phone the nearest Reliance representative or write us direct for Bulletin 311.

RELIANCE ELECTRIC & ENGINEERING CO.
1079 IVANHOE ROAD • CLEVELAND 10, OHIO
Sales Representatives in Principal Cities

RELIANCE V★S DRIVE

Available in the Electronic System (1 to 5 hp.), in the Rotating System (1 to 200 hp.), or in a combination of both systems.

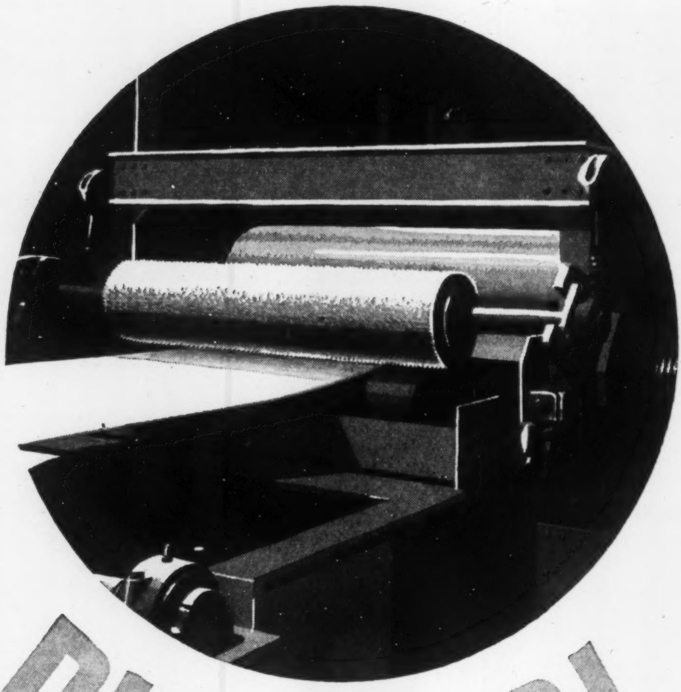


Reliance V★S Drive provides unlimited flexibility of machine operation. Starting, stopping, speed changing, reversing, maintenance of proper tension and other functions are exercised automatically or manually from nearby or remote stations.

RELIANCE A-C D-C MOTORS

"MOTOR-DRIVE IS MORE THAN POWER"

Pickled steel gets a PICK-UP!



● Stainless steel sheets pickled in nitric and sulphuric acid baths must be finished off with a hot water scrubbing. That calls for a tough brush . . . and Pittsburgh Brushes get the call from all important strip steel producers. ● Many brushes wilt quickly when contact is made with hot water-sprayed steel sheets, but Pittsburgh's dense fill of white tampico and Bahia fibre mixture, spiral wound and evenly trimed, stands up under the heaviest punishment. Fine stainless steel wire wound mandrels are also available.

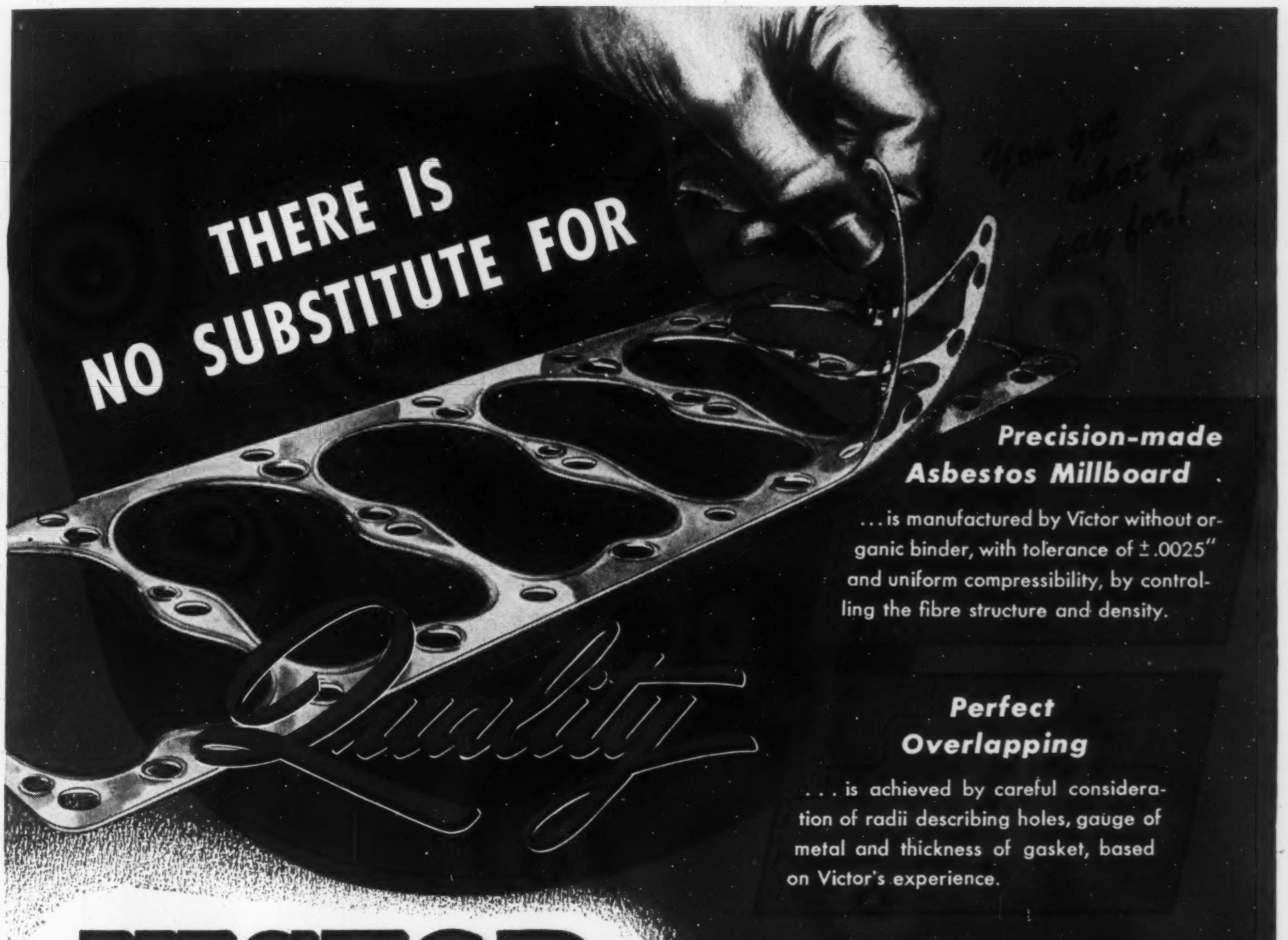
Why the Pittsburgh Plate Glass Company Makes Brushes

As a leading manufacturer of paints, Pittsburgh found that a reliable source of quality brushes was necessary for the proper application of its products. For over 40 years, Pittsburgh has made its own paint brushes. It was a natural step to extend its engineering and manufacturing facilities by developing production, maintenance and power-driven brushes engineered to the specific needs of industry.

Back the All-American "Scrub Team" of Pittsburgh Brushes

● A Pittsburgh Brush does the job fast and gives you a uniformly finished product. You can depend on Pittsburgh Brushes for better performance, enduring economy, and a minimum of lost time in changeovers. In the complete Pittsburgh line are brushes of all types, including "Perfect Balance" sections, wheels and section assemblies, Uni-Fill scratch brushes, as well as paint and other maintenance brushes. ● Consult with the Pittsburgh engineering representative. He will gladly work with you in developing any type of power-driven brushes to meet your particular finishing requirements.

PITTSBURGH
PLATE GLASS COMPANY *Brush Division*
3221 FREDERICK AVENUE · BALTIMORE—29 · MARYLAND



You get what you pay for!

Precision-made Asbestos Millboard

. . . is manufactured by Victor without organic binder, with tolerance of ±.0025" and uniform compressibility, by controlling the fibre structure and density.

Perfect Overlapping

. . . is achieved by careful consideration of radii describing holes, gauge of metal and thickness of gasket, based on Victor's experience.

Accurately Cut with Steel Dies

. . . made by Victor's skilled tool and die makers, Victor gaskets are uniform and fit perfectly as original or replacement part for the engine.

Exact Dimensions

. . . which conform to all manufacturers' specifications are followed in producing gaskets that line with motor block openings and studs.

VICTOR

The Greatest Name in the Gasket Industry

. . . has been built through years of painstaking research, craftsmanship and attention to manufacturing detail. As compression ratios of auto motors increased, with corresponding increases in pressure and temperature, Victor began to produce their own Asbestos Millboard. Experience has enabled them to develop accurate tables for computing perfect overlapping. And, since all gasket dies are produced by Victor craftsmen, accurate fitting is assured.

Victor's experience, research and production facilities are available to you. We welcome the chance to study your problem. VICTOR MANUFACTURING AND GASKET COMPANY, Box 1333, Chicago 90, Illinois.

Manufacturer of **SEALING PRODUCTS** *Exclusively*

VICTOR
GASKETS AND OIL SEALS
SEALING PRODUCTS
THROUGH
RESEARCH

VICTOR

GASKETS • OIL SEALS

YOU WILL FIND

WELLMAN

A GOOD SOURCE OF SUPPLY FOR

Sand Castings · Patterns

ALUMINUM · MAGNESIUM · BRONZE **WOOD · METAL**

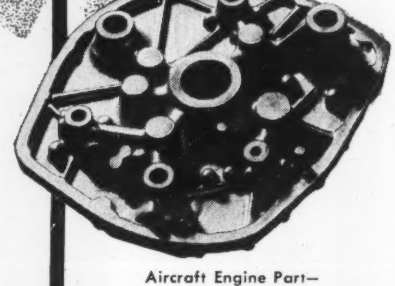
If you use non-ferrous sand castings consider the following advantages offered by Wellman:

EXPERIENCE—37 years' experience in aluminum and 16 years' experience in magnesium . . . frequently enables us to get into production on new castings months earlier.

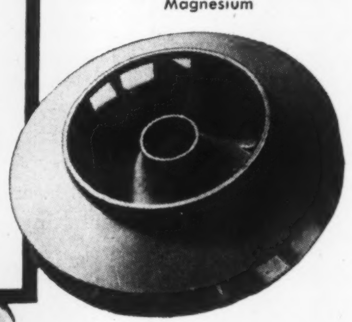
SKILL — thoroughly trained workmen in all departments . . . results in high quality and accuracy in both patterns and castings.

FACILITIES — three up-to-date plants—two foundries and a modern, well-equipped pattern shop for both wood and metal patterns; modern laboratories employing the finest equipment.

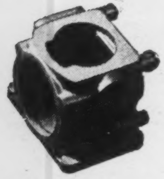
Send blueprints for quotation or we shall be glad to have a field representative call.



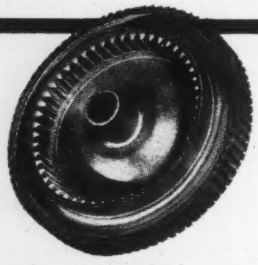
Aircraft Engine Part—
Magnesium



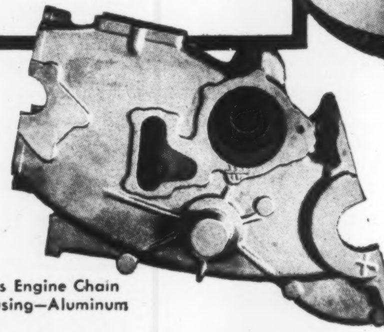
Blower—Magnesium



Portable Tool Part—
Magnesium



Lawnmower Wheel—
Aluminum



Bus Engine Chain
Housing—Aluminum

THE WELLMAN BRONZE & ALUMINUM COMPANY

GENERAL OFFICES:
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CASTINGS X-RAY INSPECTED

Purchasing Agent

"He cuts his costs—by using Fiberglas-Reinforced Plastics"*

Many alert designers and manufacturers are surprising their competitors and expanding markets by using Fiberglas Type 503 Mat (T-36), to lower costs in the construction of complete products or component parts. It provides the advantages of Fiberglas' unique combination of characteristics and can be used in either high or low-pressure laminating equipment . . . There are now fully developed production techniques which, in combination with low-cost Type 503 Mat (T-36), permit modern, high-speed production of reinforced plastics formed parts . . . If you are designing or manufacturing products which must have high tensile and impact strength, light weight, low moisture pickup and dimensional stability over a wide range of temperature and moisture changes, get complete information about Fiberglas-Reinforced Plastics now.

Let us send you a sample of Type 503 (T-36) and a copy of the new booklet describing the various other forms of Fiberglas plastics reinforcing materials. The quantity production process is also described and illustrated. Write: Owens-Corning Fiberglas Corporation, Dept. 808, Toledo 1, Ohio. Branches in principal cities.

In Canada: Fiberglas Canada Ltd., Toronto, Ontario.

OWENS-CORNING
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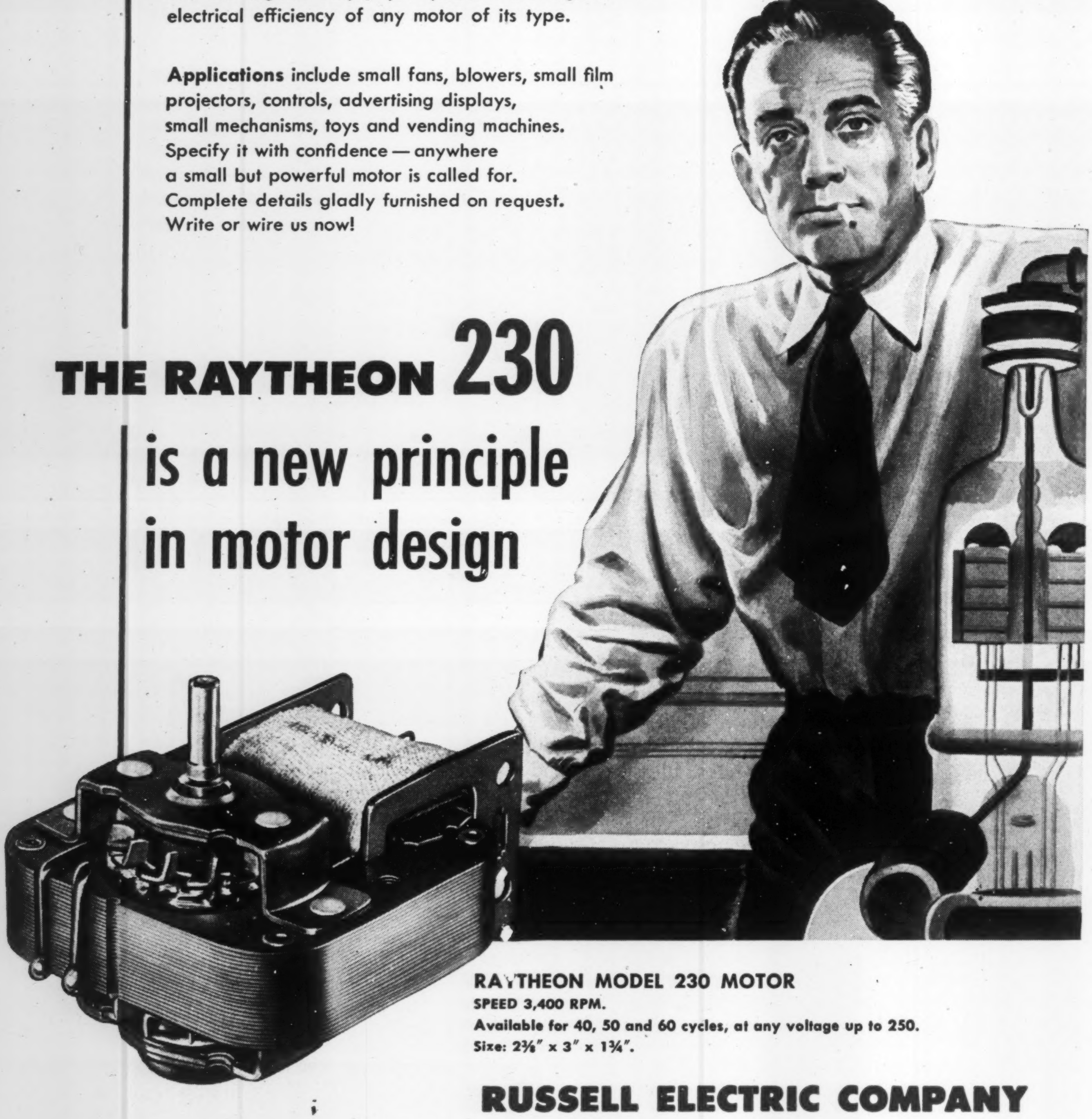
*FIBERGLAS is the trade mark (Reg. U. S. Pat. Off.) for a variety of products made of or with glass fibers by Owens-Corning Fiberglas Corporation.

Compare! Before you specify—compare the electrical efficiency—the starting torque of the precision-engineered Raytheon Model 230 Motor. It's not only a brand-new motor design—it's a brand-new *principle* in motors! For its size, it has the highest output per pound—the highest electrical efficiency of any motor of its type.

Applications include small fans, blowers, small film projectors, controls, advertising displays, small mechanisms, toys and vending machines. Specify it with confidence—anywhere a small but powerful motor is called for. Complete details gladly furnished on request. Write or wire us now!

THE RAYTHEON 230 is a new principle in motor design



RAYTHEON MODEL 230 MOTOR

SPEED 3,400 RPM.

Available for 40, 50 and 60 cycles, at any voltage up to 250.

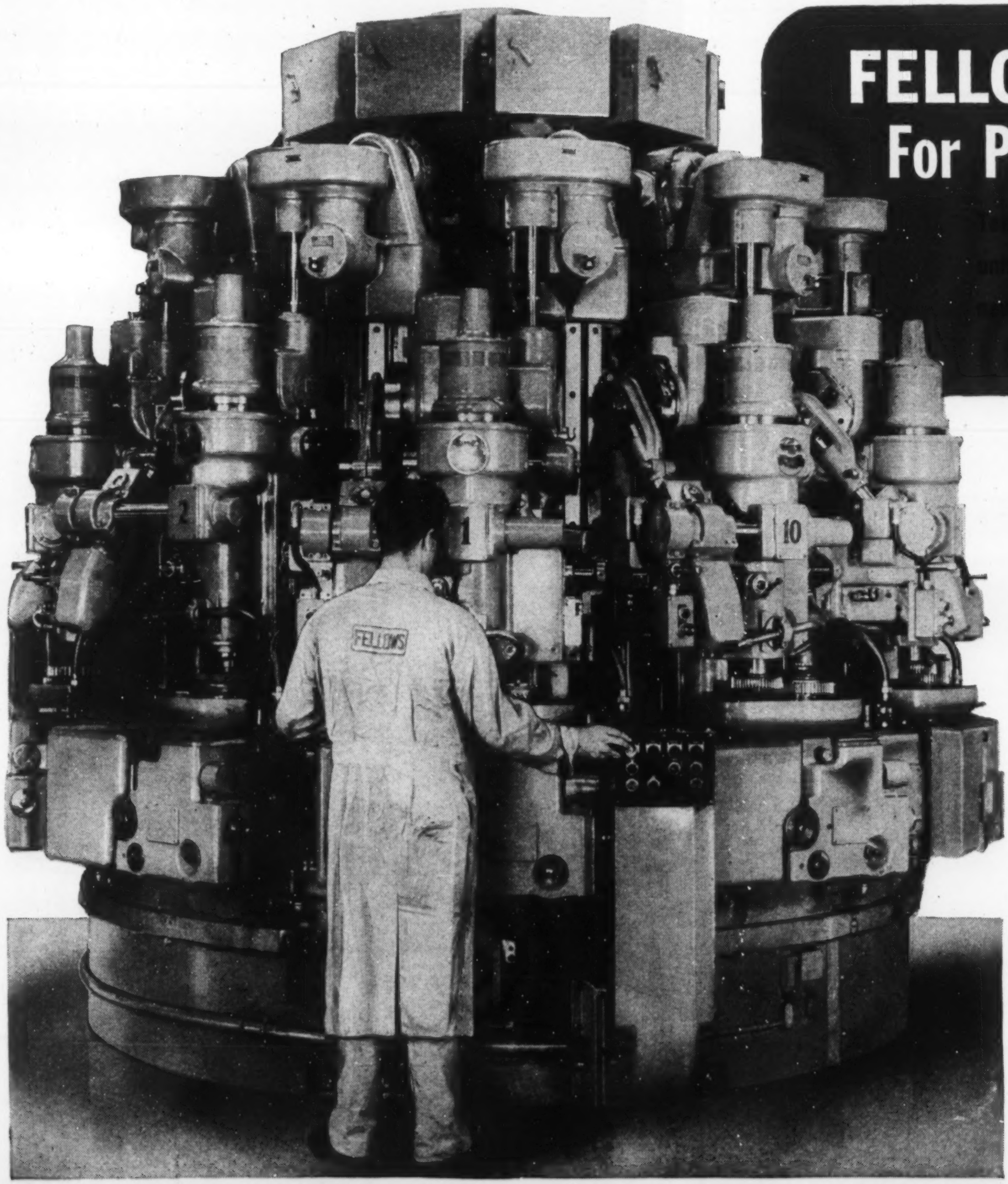
Size: 2⅜" x 3" x 1¾".

RUSSELL ELECTRIC COMPANY

344 West Huron Street • Chicago, Illinois

FELLOWS No. 10 ROTARY
For Production Gear Cutting

Ten complete and independently-controlled gear generating units, turret-mounted to rotate on a single base... an outstanding new design with characteristic Fellows versatility and accuracy.



For the Designers' Interest

- Gear Shaper precision permits the setting of closer tolerances.
- Ten "station" principle (each unit independently adjustable) permits multi-step gears to be turned out on one machine—by transferring from station to station.
- Reciprocating cutter principle permits generating teeth or other shapes externally and internally.
- Adjustable saddle beds which dispense with raising blocks, having a maximum movement of 6 inches.
- Capacity up to 12 inches pitch diameter, external, 3 inches face width, 3/4 diametral pitch, spur, 5/7 helical. (Internal gear capacity governed by blank design and size of cutter used.)

Fellows

Ask for a new bulletin on the Rotary Gear Shaper. Write: The Fellows Gear Shaper Company, Head Office and Export Dept., Springfield, Vermont. Branch Offices: 616 Fisher Bldg., Detroit 2; 640 West Town Office Bldg., Chicago 12; 7706 Empire State Bldg., New York 1.

THE FELLOWS METHOD: MACHINES AND TOOLS FOR ALL OPERATIONS FROM BLANK TO FINISHED GEAR

NEW REVERSING CONTACTOR

STRUTHERS-DUNN
STRUTHERS-DUNN

TYPE 135 KXX *Actual Size*

These District Engineering Offices To Serve You

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Much Smaller—Much Lower in Cost
Fully Dependable for Heavy Duty Service

RATING—1 HP polyphase, ¾ HP single phase, to 600 volts AC.

FEATURES—Small Size—5¾" x 4" x 1⅞".
Mechanically Interlocked.
Solid Frame—no laminations.
Simple Maintenance—all parts removable from front; all fixed contacts alike, all moving contacts alike.
Cost—appreciably lower than conventional units.

APPLICATIONS—Heavy duty reversing and jogging service such as hoists, door operators, and machine tool auxiliaries.

S-D
STRUTHERS-DUNN, INC.

STRUTHERS-DUNN

5,312 RELAY TYPES

STRUTHERS-DUNN, INC., 150 N. 13th St., Philadelphia 7, Pa.

NEW HEAVY DUTY
Semi-Pneumatic
AIR KING TIRES

for puncture-proof service on portable and material handling equipment

AIR-KING HEAVY DUTY
OHIO

AIR KING *Heavy Duty* Tires are FULL-cushioned, shock-absorbing, puncture-proof, non-skid, and wear-resistant. Modern techniques of engineering, manufacturing, and testing assure uniformly high standards of quality.

Among their wide diversity of applications, either as original equipment by manufacturers of wheel goods, or for replacement by owners of portable and material handling equipment, are the following typical applications:

- Aisle Marking Machines
- Arc Welding Machines
- Barrel and Drum Trucks
- Battery Charging Machines
- Car Washers
- Contractors' Pumps
- Cooling Fans
- Floor Sweeping Machines
- Hand Trucks
- Hospital Equipment
- Insecticide Sprayers
- Lubricating Equipment
- Paint Sprayers
- Tote Trucks
- Traffic Line Markers
- Sidewalk Snow Plows
- Wheelbarrows
- Misc. Portable Equipment

Standard sizes of *Heavy Duty* AIR KING TIRES range from 6" x 2.00" to 16" x 4.00" with respective load ratings from 150 lbs. to 625 lbs. per tire. Other sizes and load ratings made to specifications. There's an AIR KING TIRE to meet YOUR particular needs. Our representative in your area will be glad to discuss details. Write:

THE OHIO RUBBER COMPANY
WILLOUGHBY, OHIO

OHIO RUBBER CO

FACTORIES: WILLOUGHBY, OHIO • LONG BEACH, CALIF. • CONNEAUTVILLE, PA.
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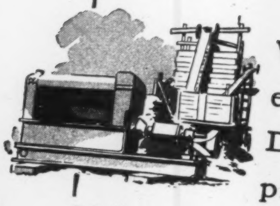
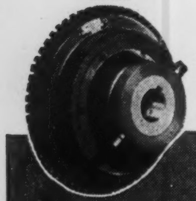
Twin Disc Hydraulic Drives for

2-WAY PROFITS

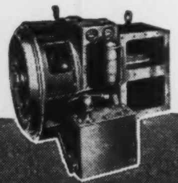


When you equip your engine with a Twin Disc Hydraulic Coupling (Bulletin No. 136), you take a step that will increase your profits two ways. First, the hydraulic coupling *cuts overall maintenance costs* on both engine and driven machinery and reduces down-time because destructive shock loads are "cushioned" by the coupling. Second, the hydraulic coupling assures a *faster work cycle* . . . a smoother, more flexible flow of power . . . rapid acceleration . . . full delivery of input torque at every output speed. For the full story on how Twin Disc Hydraulic Couplings can increase your profits two ways, write to the TWIN DISC CLUTCH COMPANY, Racine, Wisconsin (Hydraulic Division, Rockford, Illinois).

Heavy Duty Clutch



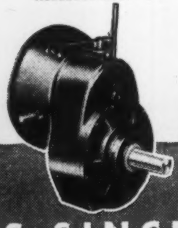
Hydraulic Torque Converter



Machine Tool Clutch

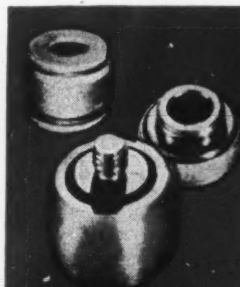
TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES
REG. U. S. PAT. OFF.

Reduction Gear



Marine Gear

SPECIALISTS IN INDUSTRIAL CLUTCHES SINCE 1918

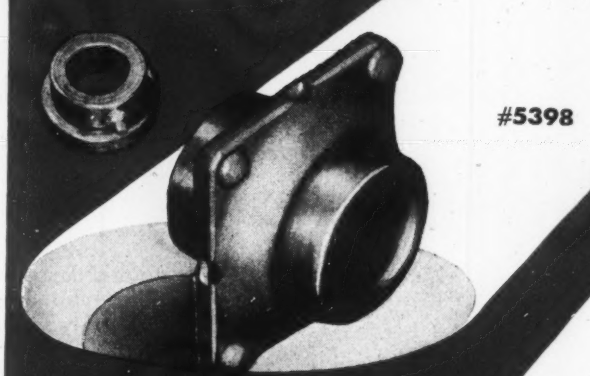


NICE

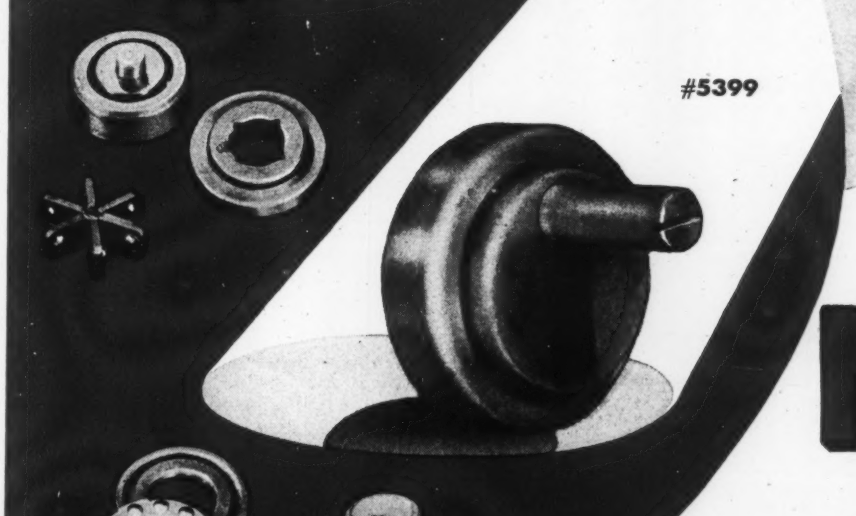
Specialists in "Specials"

NICE Engineers are recognized for their experience and ingenuity in designing and producing ball bearings that economically meet unusual requirements. These "specials," like Nice standard bearings, can be constructed of non-corrosive materials, such as stainless steel, brass or bronze . . . with special features, such as dust shields, grease seals, extended inner races with grease fittings, etc., where applicable and when warranted by quantities involved. A few of these special bearings are shown.

#5788



#5398



#5399

#5788 — Thrust or radial type with full floating center race. End races are integral. The load is absorbed by the two extending pins on center race. Produced for tractor governors.

#5398 — Radial type bearing with square outer housing with oil holes. Square form allows ease of installation and prevents outer housing from turning. Produced for domestic washing machine wringer rolls.

#5399—Combination bearing with eccentric stud. Designed for thrust loads but capable of taking radial loads created by eccentric motion. Used for vibrating, sorting and grading machinery.

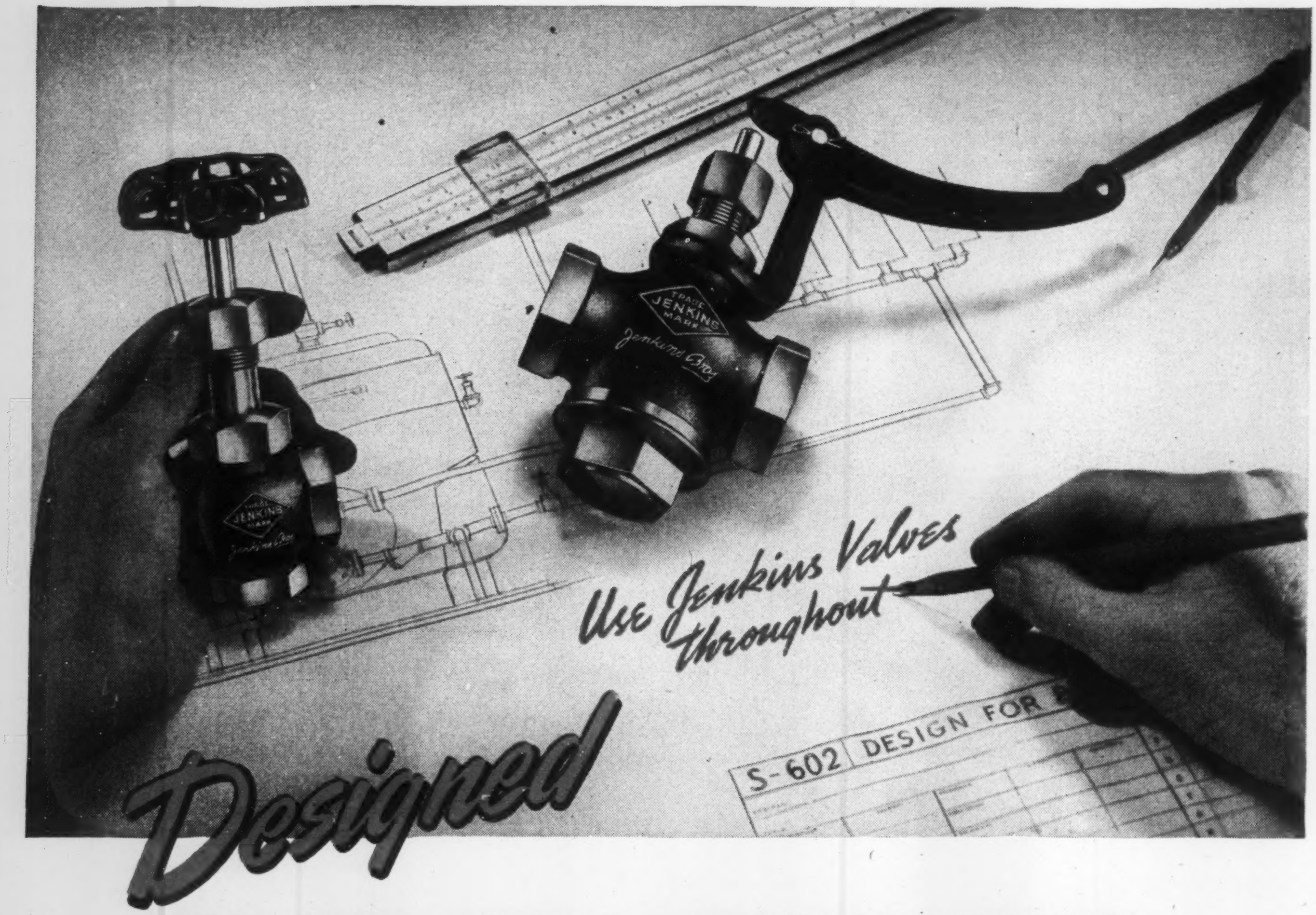
HAVE YOU ANY SPECIAL REQUIREMENTS ON WHICH WE MAY WORK?

NICE

Ball Bearings

NICE

NICE BALL BEARING CO.
NICETOWN, PHILADELPHIA 40, PA.



FOR "BED ROCK" SERVICING EXPENSE

In any product where fluid control is a function of operation, unsatisfactory performance can often be traced to valves. Continuous, costly servicing quickly wipes out "savings" made by using inferior valves, cuts into profits . . . may give an otherwise fine product a "black eye."

Trouble-free performance can be designed into your product — by specifying Jenkins Valves. If you choose the right Jenkins Valves for the service, and locate them correctly, you can rest assured of bed rock valve servicing costs, even under the toughest conditions.

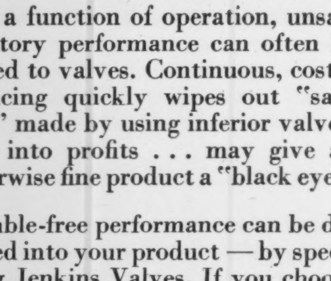
You also profit by Jenkins long experience in supplying valves for all types of products. You add the valve know-how of Jenkins Engineers, whenever necessary, to your own designing skill.

Most important, you gain a definite sales advantage by enlisting the established customer-confidence in Jenkins Valves, built up over 83 years by providing *extra value* in valves, and by continuous industry-wide advertising. To your prospects, the famous Jenkins Diamond and Signature trade mark on valves indicates equally high quality construction throughout.

In planning any product requiring valves, use the new Jenkins Designers' Kit. It will save you time whenever you need to answer the question, "*Which* type of valve *where* for best performance?" When more help is desired, ask Jenkins Engineers to work with you on any problem of selection.

Give your product and its purchasers, the *extra value* of Jenkins Valves . . . *it costs no more.*

Jenkins Bros., 80 White Street, New York 13; Bridgeport, Conn.; Atlanta; Boston; Philadelphia; Chicago; San Francisco. Jenkins Bros., Ltd., Montreal.



GET JENKINS DESIGNERS' KIT. A handy file of valve information needed by product development men . . . helps answer the question — "Which type of valve where for best performance?" Mail the coupon.

JENKINS BROS., 80 White St., New York 13

Please send me the Jenkins Designers' Kit.

Name...

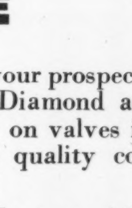
Company...

Address...

LOOK FOR THIS DIAMOND MARK

SINCE *Jenkins Bros* 1864

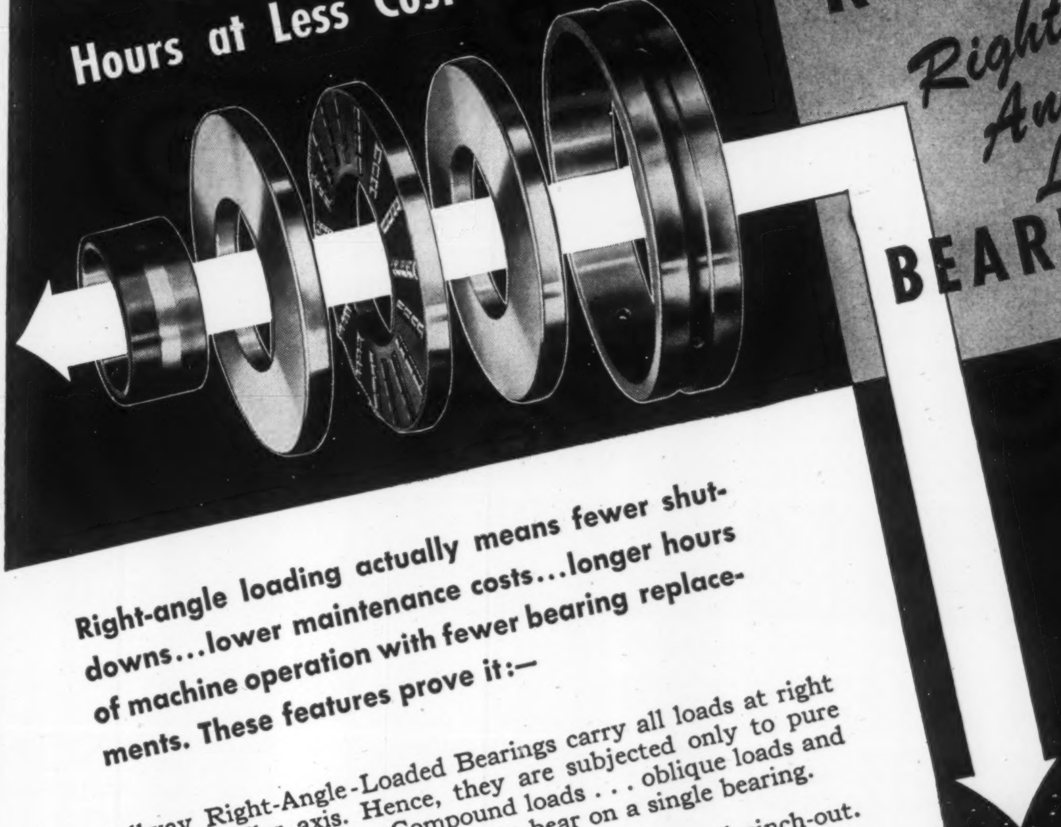
JENKINS VALVES

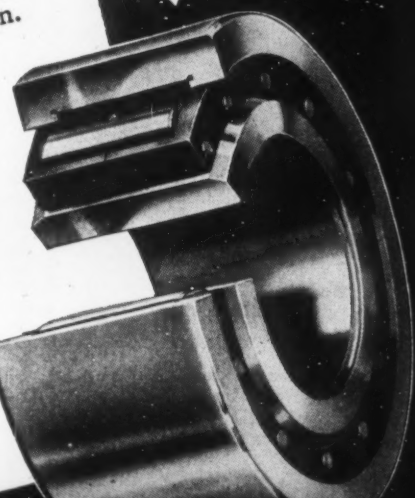


Types, Sizes, Pressures, Metals for Every Need

Get More Man and Machine Hours at Less Cost . . .

ROLLWAY
Right-Angle-Loaded
BEARINGS





Right-angle loading actually means fewer shut-downs...lower maintenance costs...longer hours of machine operation with fewer bearing replacements. These features prove it:—

1. Rollway Right-Angle-Loaded Bearings carry all loads at right angle to the roller axis. Hence, they are subjected only to pure thrust or pure radial loads. Compound loads . . . oblique loads and their resultants . . . are not brought to bear on a single bearing.

2. Right-angle loading prevents wedging of rollers and pinch-out. Greatly reduces roller end-rub . . . wear-back and rubbing friction.

3. Permits greater radial or thrust load-carrying capacity in any given dimension.

4. Assures solid cylindrical rollers of greater roller mass and uniform roller cross-section.

5. Assures greater resistance to shock loads and vibration . . . longer life expectancy under continuous heavy-duty service.

ROLLWAY BEARING COMPANY, INC., SYRACUSE, N. Y.
SALES OFFICES
Philadelphia Boston Minneapolis Pittsburgh Houston Cleveland Los Angeles Detroit Chicago

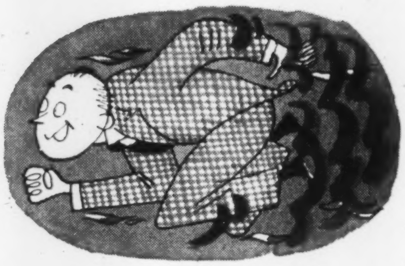
FREE SERVICE! Send us a print or detailed statement of your bearing problems. Our engineers will make an analysis and recommend the exactly right bearing for your particular needs.

ROLLWAY BEARINGS

Sid was sick of shortages—so...

1. . . . he finally decided to convert to aluminum.

2. His competitor, Carl, just laughed. "Aluminum can't be adapted to Sid's product," Carl chortled.

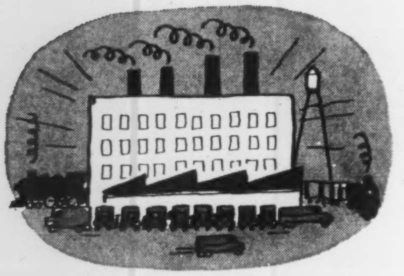


3. But Sid was off like a fireball! For he'd learned that alloys of Kaiser Aluminum could meet almost every type of operation. And it could be formed, drawn, spun, brazed or joined.

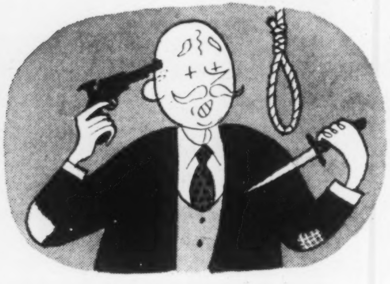
4. "So alright, he did it," shrugged Carl, "but the cost will break him."

5. But foxy Sid found that though aluminum costs a little more to begin with, savings in handling, fabricating, finishing and shipping more than made up the difference.

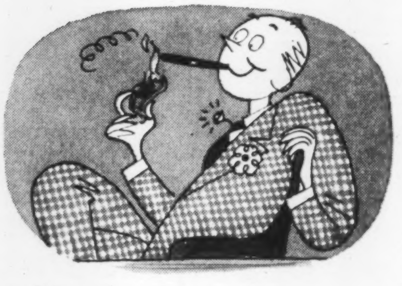
6. Still, die-hard Carl wouldn't budge. No siree, he'd wait for the metal he had *always* used.



7. Meanwhile, Sid's product sold like popcorn at a circus. Folks preferred aluminum products. Result: Soaring production cut costs still further.



8. Now, would you rather be Carl?



9. . . . or Sid?

MORAL: Alert manufacturers — making everything from general appliances to residential buildings, from garage doors to heating and ventilating ducts — are speeding production, nailing down new markets . . . by converting to *Kaiser Aluminum.* The problems solved by them can help *you.* So call in a Permanente engineer *today!*

Ready to serve you—*today*...

Kaiser Aluminum

a Permanente Metals product

DISTRIBUTED BY PERMANENTE PRODUCTS COMPANY, KAISER BLDG., OAKLAND, CALIFORNIA . . . WITH OFFICES IN:
Seattle • Oakland • Los Angeles • Dallas • Wichita • Kansas City • St. Louis • Atlanta • Minneapolis • Milwaukee • Chicago
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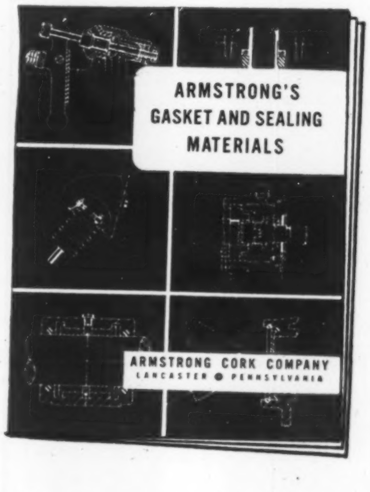
FACTORS IN CHOOSING RESILIENT GASKETS
SEALING WITH CONFINED RESILIENT GASKETS
DESIGNING GASKETS TO REDUCE COST
FIGURE 1
FIGURE 2
FIGURE 3
12
ARMSTRONG CORK COMP

DESIGNING GASKETS TO REDUCE COST



ARMSTRONG'S GASKET AND SEALING MATERIALS

ARMSTRONG CORK COMPANY
LANCASTER ● PENNSYLVANIA

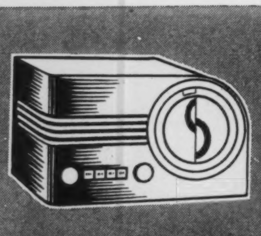
PARTIAL CONTENTS: Designing Flanges for Efficient Sealing, Designing Gaskets to Reduce Cost, Effect of Gasket Width on Compression, Effect of Surface Condition on Gaskets, Factors in Choosing Resilient Gaskets, Proper Compression for Resilient Gaskets, Relation of Gasket Thickness to Load, etc.

DATA that can help you reduce gasket costs, such as encircled above, are only a small part of the design information given in "Armstrong's Gasket and Sealing Materials." This new 20-page booklet is as useful to designers and engineers as it is to purchasing men.

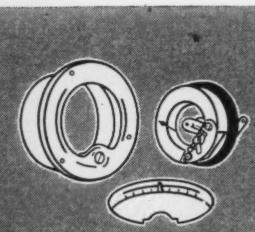
As you know, many variables influence the design of gaskets and gasketed joints. Most of these variables are discussed in "Armstrong's Gasket and Sealing Materials." In addition to these technical discussions, this booklet contains physical data on the five major types of sealing materials offered by Armstrong: synthetic rubber compounds, cork-and-synthetic-rubber compositions, cork compositions, fiber sheet packings, and rag felt paper in both plain and saturated types.

You'll find "Armstrong's Gasket and Sealing Materials" a helpful addition to your files. Refer to it whenever you need data to make tentative selections of suitable resilient materials. Write for your copy today. Armstrong Cork Company, Gaskets and Packings Dept., 5111 Arch St., Lancaster, Pa.

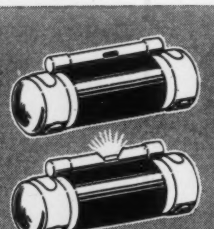
ARMSTRONG'S GASKETS • PACKINGS • SEALS



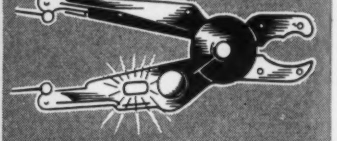
Decorative colors and clear scale-markings with internal lighting



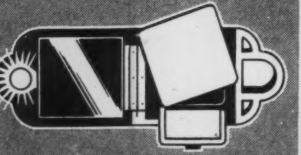
Internal lighting makes meters easier to read



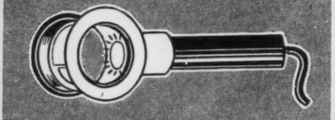
Blown fuses quickly spotted by built-in glow lamps



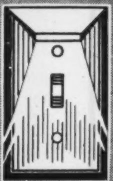
Fuse puller with built-in glow lamp as tester



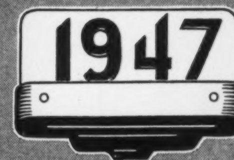
This compact also carries battery and bulb



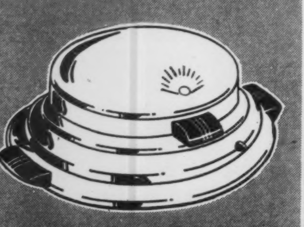
Stamp collector's illuminated magnifying glass



Switch plate with built-in glow lamp shows "on" or "off"



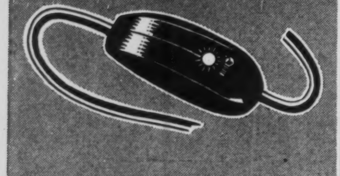
Lighted house numbers—a low-cost convenience



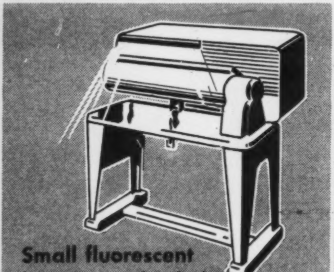
Light shines when waffles are done

A little light

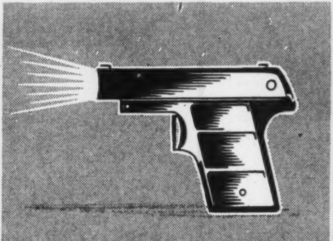
CAN MAKE YOUR PRODUCT SHINE



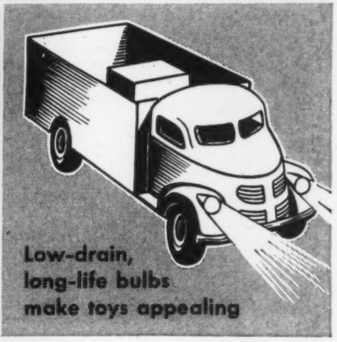
Cord switch with built-in indicator lamp



Small fluorescent lamp provides light in small space



Lighted pistol projects pictures



Low-drain, long-life bulbs make toys appealing

HOW to give your product an added edge over competition? Try using G-E miniature lamps—filament or glow!

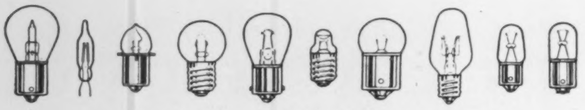
They can add safety, utility, convenience, beauty and sales appeal to hundreds of products—including industrial equipment, appliances, instruments, household items, toys, and novelties. The design ideas shown here merely hint at some of the limitless possibilities.

Whatever lamps you need, G-E makes them all! All sizes and types. All wattages and voltages. Filament and neon-glow. For delicate service and heavy duty. G-E Lamp specialists will gladly assist you in selecting the right General Electric miniature bulbs for your job.

BIG JOBS FOR SMALL BULBS

FREE BOOKLET

Shows you how G-E miniature lamps make products stand out from the rest. Contains more than 80 exciting design ideas that may suggest new ways to improve the quality of your products. Call your nearest G-E Lamp office for a free copy. Or write General Electric Co., Div.166-MD-11, Nela Park, Cleveland 12, Ohio.

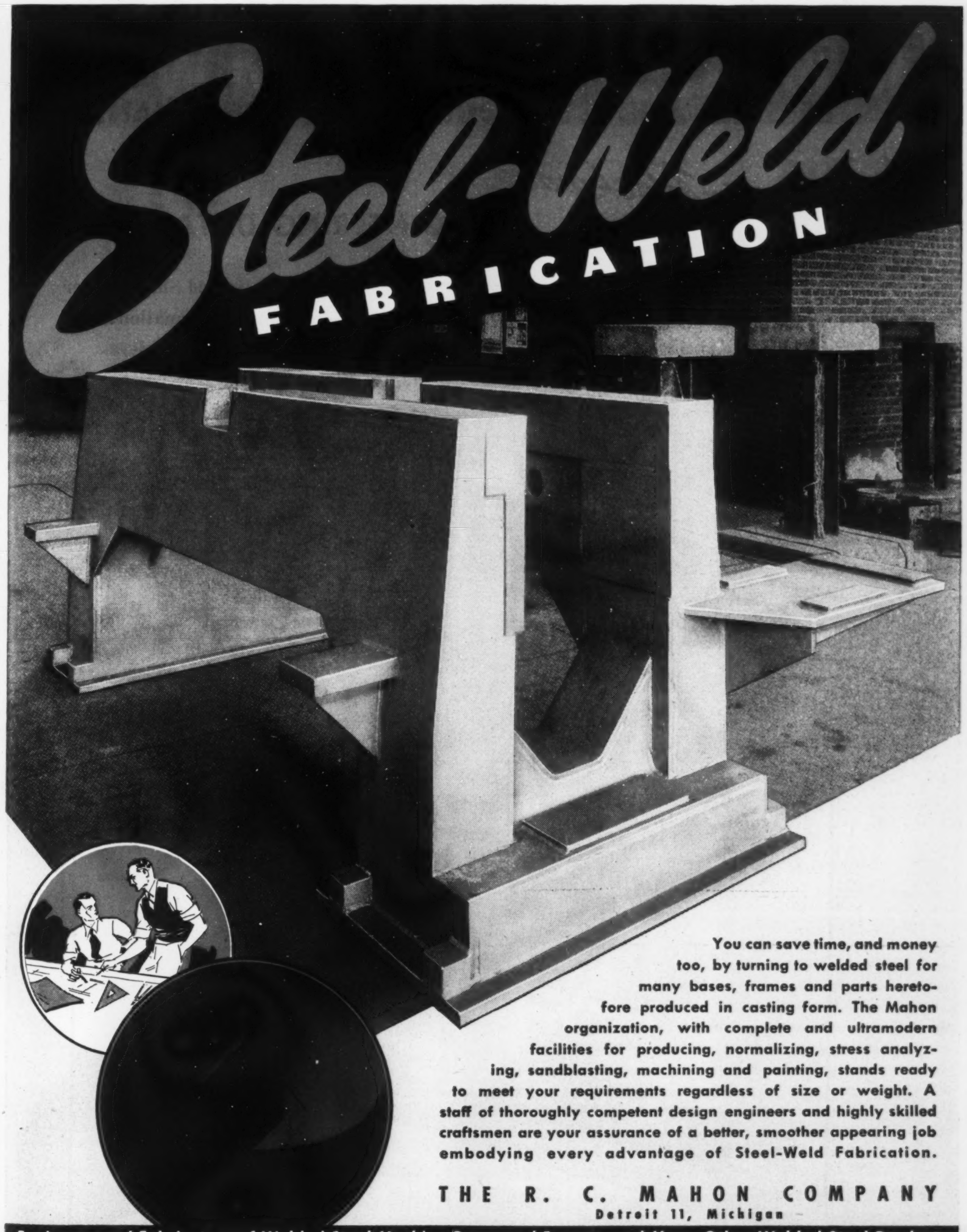


Whatever lamps you need, G-E makes 'em all!

G-E LAMPS

GENERAL ELECTRIC

Steel-Weld FABRICATION



You can save time, and money too, by turning to welded steel for many bases, frames and parts heretofore produced in casting form. The Mahon organization, with complete and ultramodern facilities for producing, normalizing, stress analyzing, sandblasting, machining and painting, stands ready to meet your requirements regardless of size or weight. A staff of thoroughly competent design engineers and highly skilled craftsmen are your assurance of a better, smoother appearing job embodying every advantage of Steel-Weld Fabrication.

THE R. C. MAHON COMPANY
Detroit 11, Michigan

Engineers and Fabricators of Welded Steel Machine Bases and Frames, and Many Other Welded Steel Products

MAHON

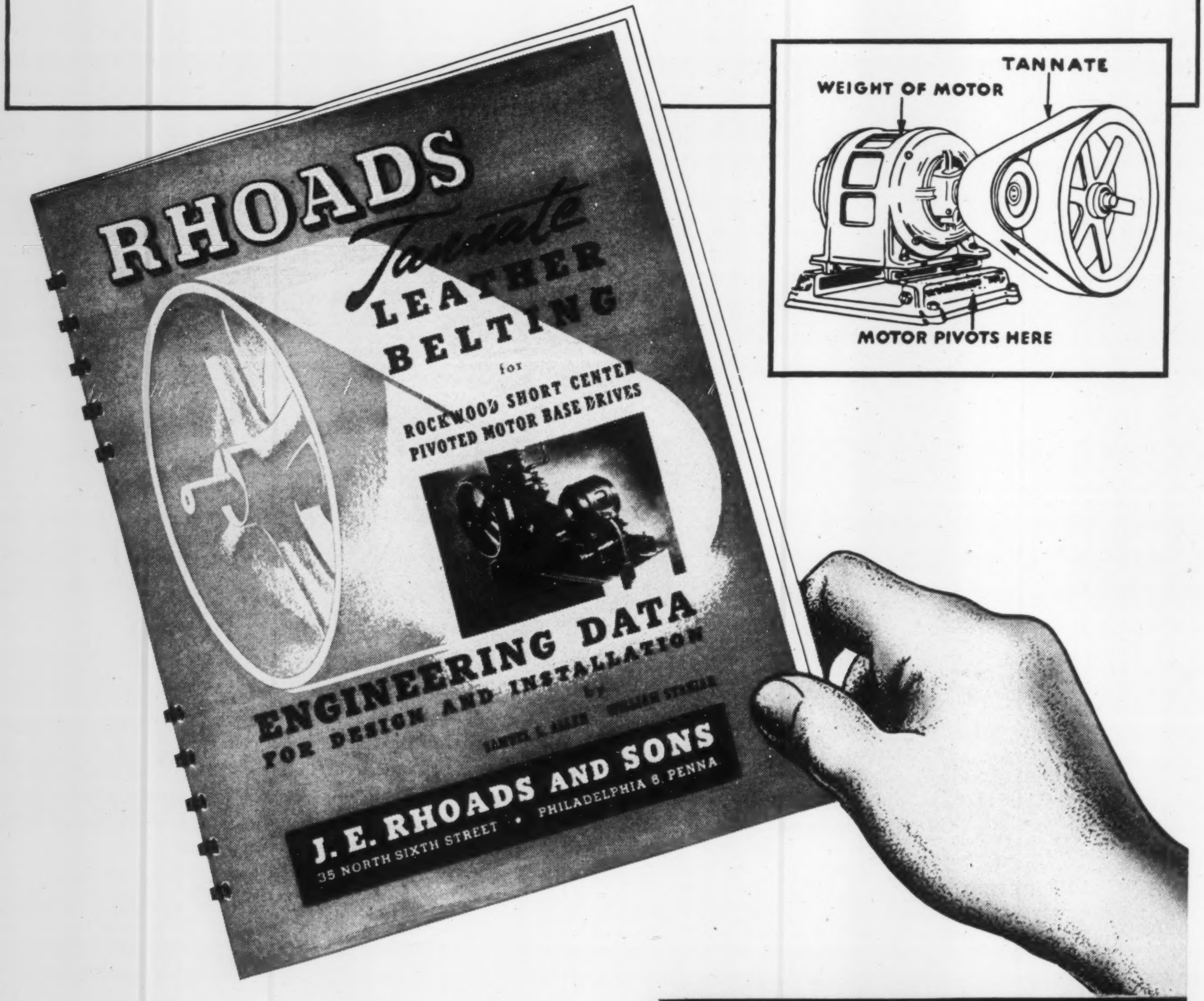
Engineers and Designers:

BE SURE AND GET YOUR COPY OF THIS HANDY

Tannate-Rockwood ENGINEERING DATA BOOK

This 23 page, flat-opening engineering data book on Tannate-Rockwood Short Center Drives gives complete specifications, dimensions and other pertinent information about the design and installation of these production-increasing, cost-reducing drives.

Write today, for your free copy of this valuable, time-saving reference book—on your business letterhead, please.



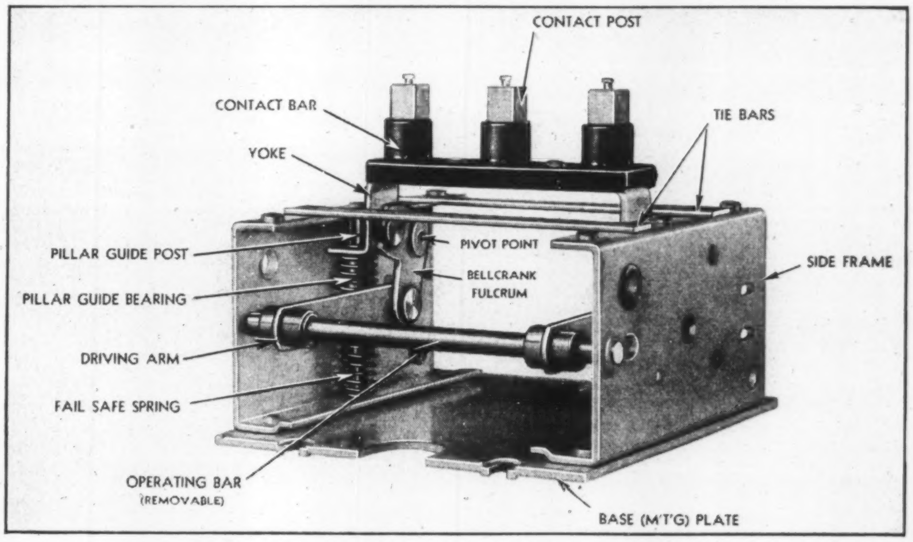
RHOADS
Tannate
LEATHER
BELTING
for
ROCKWOOD SHORT CENTER
PIVOTED MOTOR BASE DRIVES
ENGINEERING DATA
FOR DESIGN AND INSTALLATION
by

J. E. RHOADS AND SONS
35 NORTH SIXTH STREET • PHILADELPHIA 6, PENNA

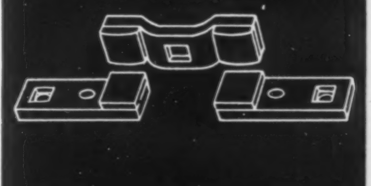
PRODUCERS OF FINE LEATHER FOR 245 YEARS

J. E. RHOADS & SONS
35 NORTH SIXTH ST., PHILA. 6, PA.
NEW YORK • CHICAGO • ATLANTA

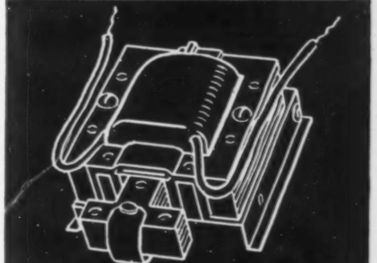
NEW MAGNETIC STARTER


CONTACT POST
CONTACT BAR
TIE BARS
YOKE
PILLAR GUIDE POST
PIVOT POINT
SIDE FRAME
BELLCRANK FULCRUM
PILLAR GUIDE BEARING
DRIVING ARM
FAIL SAFE SPRING
OPERATING BAR (REMOVABLE)
BASE (M'T'G) PLATE

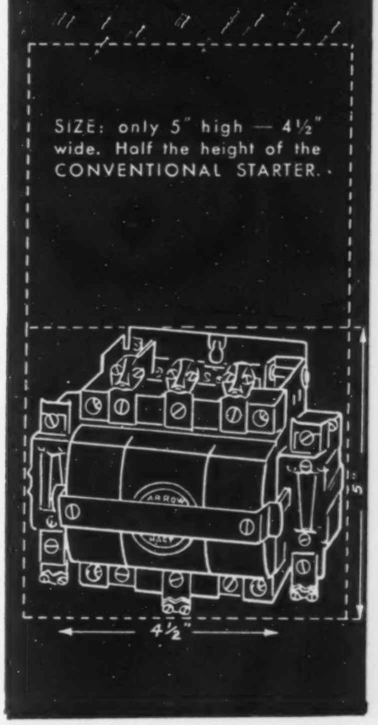
SIZE 2;
Type RA



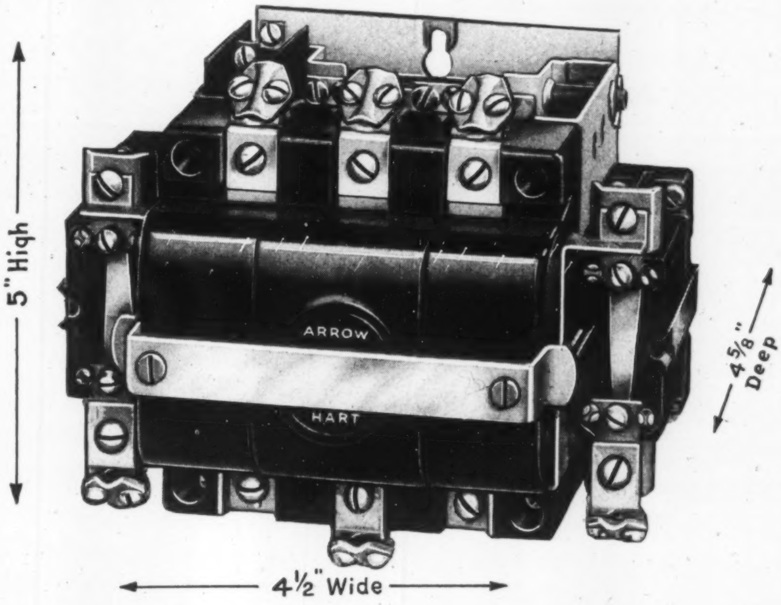
Curved movable tips against flat stationary tips give a broad line-of-contact surface which improves with use.



The 15-lb. magnet pull is multiplied to 25-lbs. at the contacts. Requires but 8.5 Watts closed, 75 Watts inrush.



SIZE: only 5" high — 4½" wide. Half the height of the CONVENTIONAL STARTER.


5" High
4⅝" Deep
4½" Wide
ARROW
HART

ARROW
AH
HART

This new-principle *balanced* mechanism provides full use of magnet power without lifting extra weight. Requires but 8.5 Watts closed; 75 W. inrush. STRAIGHT-LINE HORIZONTAL ACTION permits of unique *small size*, — only half the height of the conventional starter. Most compact, dependable control for streamlined machine designs.

THE ARROW-HART & HEGEMAN ELECTRIC COMPANY, HARTFORD 1, CONN., U.S.A.

ANTI-CORROSIVE METAL PRODUCTS CO., INC.

CASTLETON-ON-HUDSON, NEW YORK

Telephones
Albany . . 4-0321
Castleton . . 2511

18 % CHROME NICKEL 8 %

Mailing Address
Post Office Box 870
Albany 1, N. Y.

AN OPEN LETTER TO NERO WOLFE, DETECTIVE, GOURMET, AND ORCHIDIST

Mr. Nero Wolfe
c/o AMERICAN MAGAZINE
New York, New York

Dear Mr. Wolfe:

In a recent report on your activities, chronicled by your estimable assistant, Mr. Archie Goodwin, under the title "Before I Die", you are recorded as having been approached by a character involved in sundry black market operations. Mr. Goodwin further states that you asked this character to obtain for you some "stainless steel ... bolts and nuts ... rivets".

We admire your perspicacity in realizing the superiority of stainless steel products, just as we admire your investigatory abilities. But, while we are fully aware that you were only testing the capacity of this character, we think you should know that no one has to resort to illegalities when searching for stainless steel bolts, nuts, rivets, or other fastening devices. Our stock room is full of them, in all shapes and sizes, and we'll be glad to provide all you need.

We'll be delighted to send you, or anyone else, a copy of our catalog and our current stocklist, on request. Or, if your needs are for some special analysis or specification, we'll be glad to manufacture the fastenings you wish, in a very short time.

We've been making stainless steel fastenings for twenty years, and we think that our reputation, in our particular field, compares favorably with yours in the field of detection.

Sincerely,

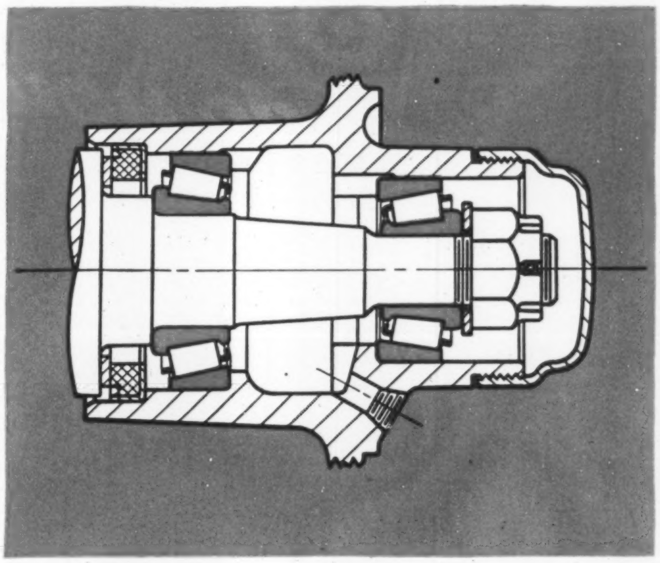
Richard Mack
Treasurer
Anti-Corrosive Metal Products Co., Inc.

Manufacturers of

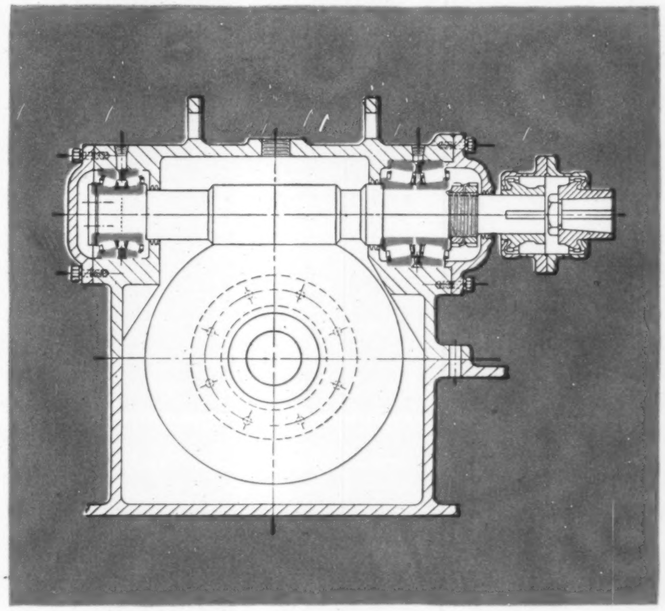
NUTS • BOLTS • RIVETS • WOOD SCREWS • MACHINE SCREWS • LOCK WASHERS • COTTER PINS • NAILS
SEAMLESS PIPE • *Carried in Stock* • PIPE FITTINGS

Anyone else who would like a copy of our catalog and our current stocklist? Write Anti-Corrosive Metal Products Co., Inc., 57 River Road, Castleton-on-Hudson, N. Y.

How to carry combinations of radial and thrust loads



TRACTOR FRONT WHEEL *in which both thrust and radial loads are carried on single row Timken bearings. From whichever way the load may come, it will be handled with minimum friction and wear.*



APPLICATION *of Timken Bearings on the worm shaft of a worm gear drive. The load on the worm shaft bearings, due to the operation of the worm, is primarily thrust. There is considerable radial load however, arising from the separating force of the gears and also possibly from overhung driving loads. This is another application for which the tapered roller bearing is ideal.*

THESE drawings show how Timken tapered roller bearings are effectively used where both radial and thrust loads must be carried. They may give you an idea for projects now on your boards.

Because it is a *roller* bearing, the Timken bearing can carry the heaviest loads. Because its rolls are *tapered,* it can carry both radial and thrust loads in any combination.

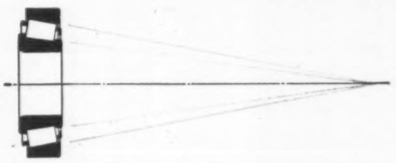
From whichever direction the loads may come, this tapered design enables the Timken bearing to carry them, one at a time or simultaneously. The cost of providing a separate type of bearing for each load is eliminated. Bearing housings and mountings are simplified, with a saving in cost, weight, and space.

For help in putting these important advantages of Timken bearings to work in the product you're designing, call upon the confidential service of the Timken engineer. He will help you select the precisely correct bearing for your job.

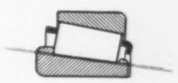
Remember, Timken is the only bearing manufacturer which makes its own steel. And Timken is the acknowledged leader in: 1. advanced design; 2. precision manufacture; 3. rigid quality control; 4. special analysis steels.

Additional copies of this page and further information on this or other applications of Timken bearings are yours for the asking. Write — The Timken Roller Bearing Company, Canton 6, Ohio.

TIMKEN GIVES YOU THESE IMPORTANT FEATURES:



1. TRUE ROLLING MOTION
All lines drawn coincident with the faces of rollers, cone and cup meet at a common point on the axis of the bearing.



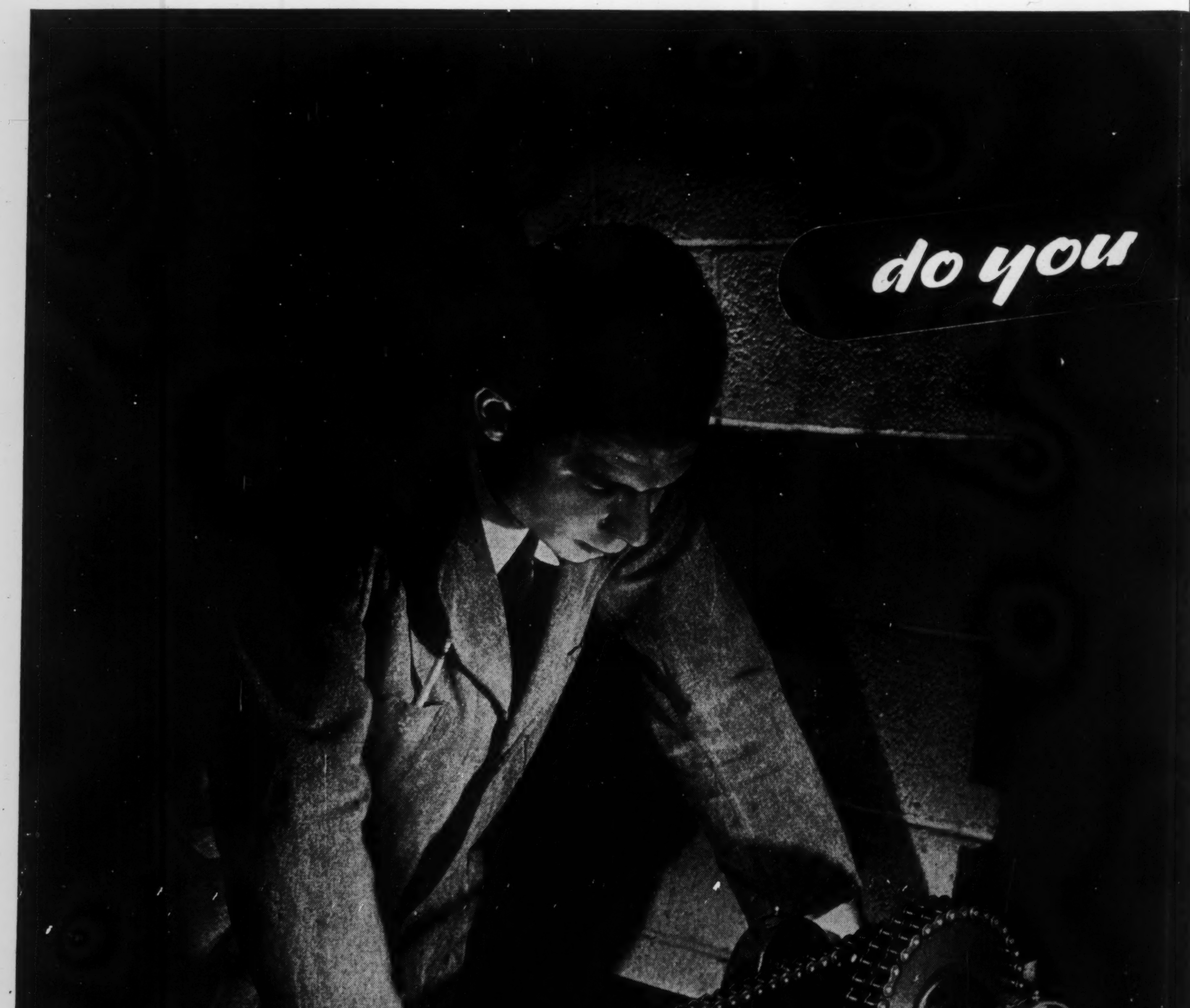
2. GREATER LOAD CAPACITY
Load is distributed along full length of roller, giving greater capacity, precision, and rigidity, with less wear and distortion.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

NOT JUST A BALL ○ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION


do you

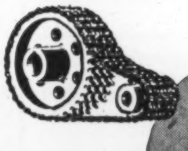
know Roller Chain...

PUTS POSITIVE PERFORMANCE IN YOUR DESIGN!

● BALDWIN-REX ROLLER CHAIN DRIVES put plus value in your machines . . . add to product salability! For example, their positive action eliminates slippage and conserves power costs. They transmit more horsepower in less space, assuring compactness. Through the use of roller chains, you get the advantage of maximum flexibility in your drive design arrangements plus the inherent elasticity that protects machines against shocks and momentary overloads. And properly applied, they usually last the lifetime of the machine.

We're not talking through our hats on that long-life statement. In our product development laboratories, we actually prove the wear-resistant abilities of Baldwin-Rex. On machines such as this, the chain is run at excessively high speeds over small sprockets under conditions considerably more severe than actually encountered to determine life expectancy. In this manner, we obtain data on choice of materials, degree of heat-treatment, and design of parts that enable us to give you the best in roller chain . . . and assure you the most economical drive for your machines.

When specifying roller chains for your machines, remember that you can simplify chain selection, generally cut costs, and improve deliveries by specifying standard roller chains. Your Baldwin-Rex man will be glad to give you all the facts and assist you with your application problems. Call him or write direct to Baldwin-Duckworth Division of Chain Belt Company.



BALDWIN·REX

ROLLER CHAINS

BALDWIN-DUCKWORTH DIVISION OF CHAIN BELT COMPANY
320 Plainfield Street, Springfield 2, Massachusetts

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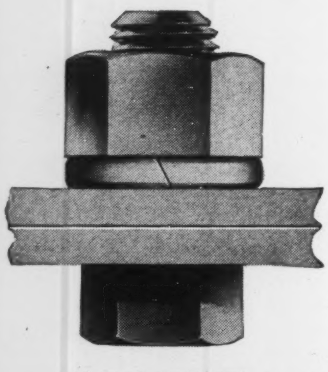

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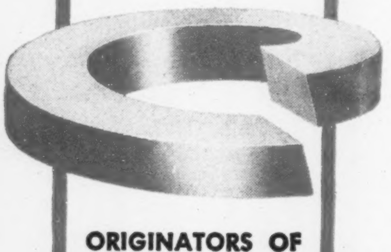

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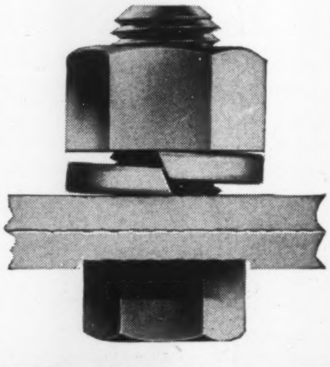

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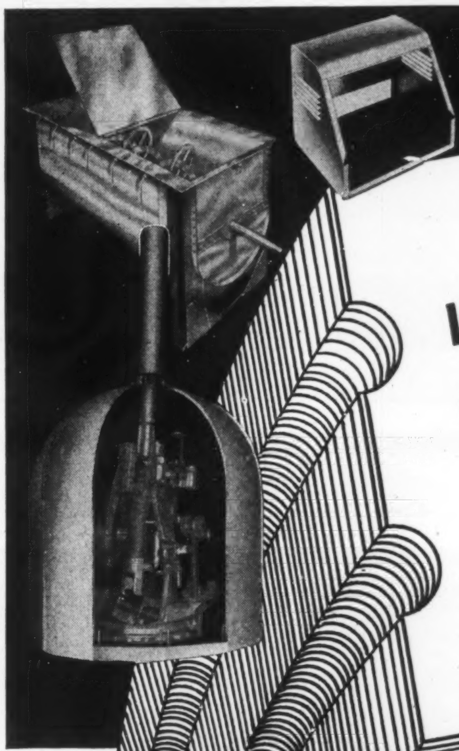

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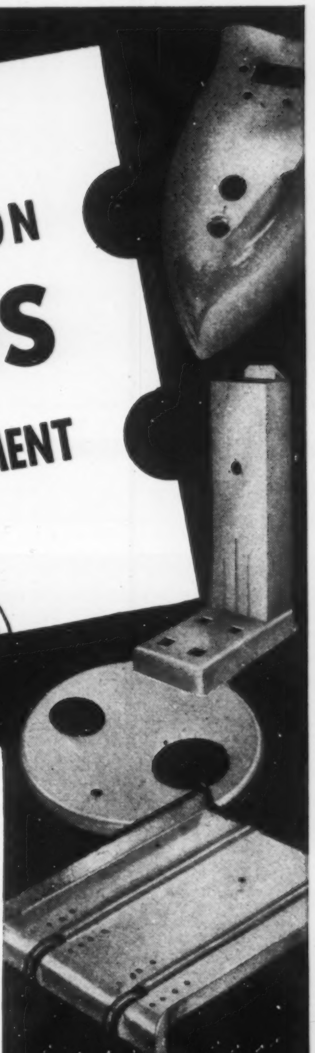

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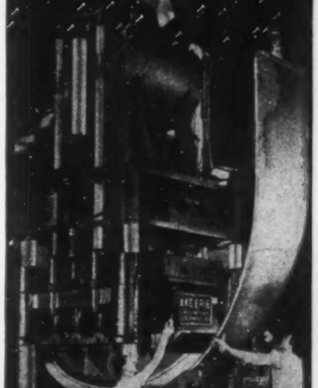

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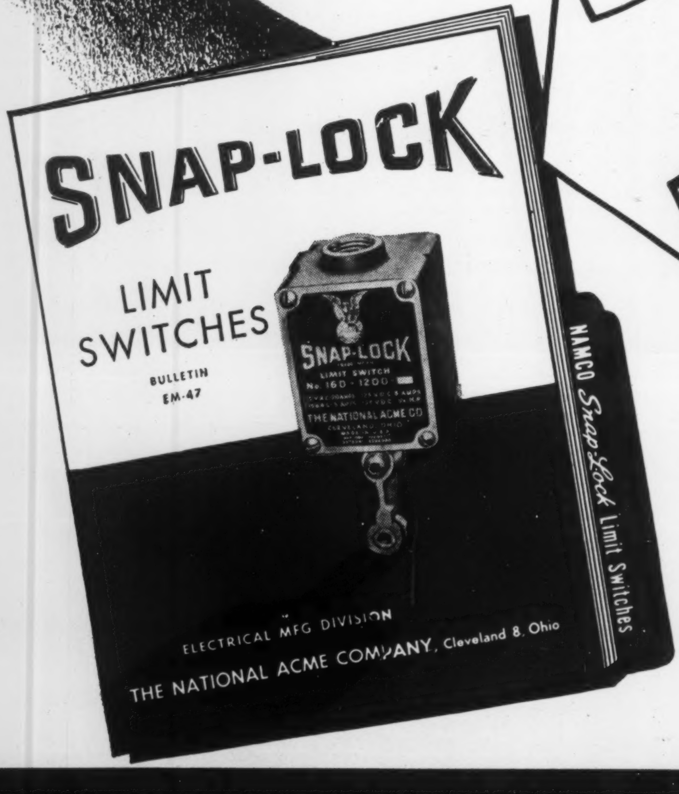

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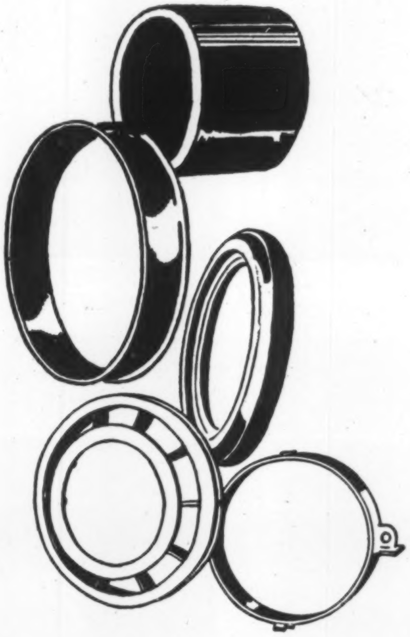

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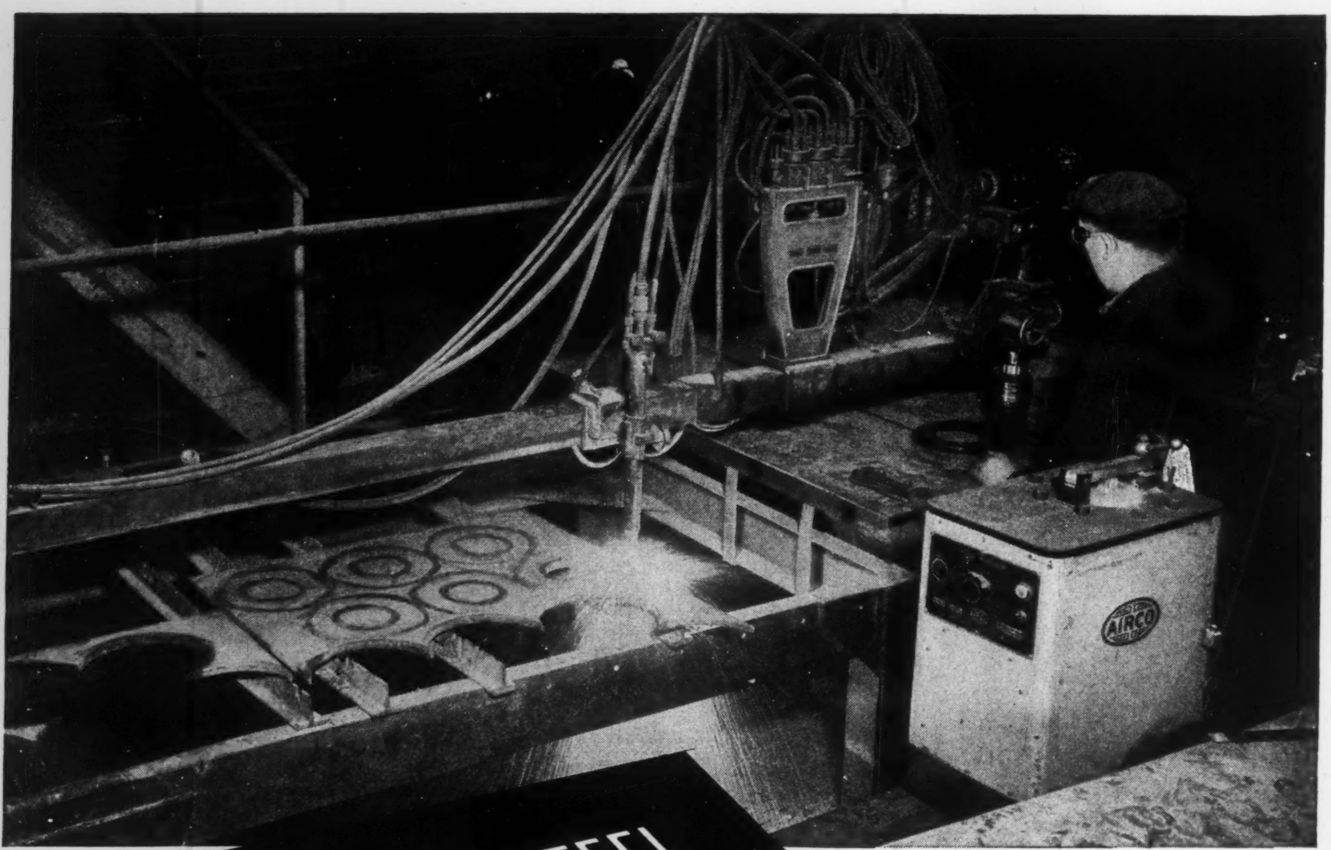

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cut ⅓ cheaper . . . and 6 times faster

That is the enthusiastic report on Airco's new Flux-Injection Method of cutting stainless steel at American Fabricators, Inc., of Louisville, Kentucky.

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Designed for use with standard Airco oxyacetylene equipment, this new Airco stainless steel cutting method keynotes simplicity, safety and production economy. It brings operating conditions for stainless steel cutting to mild steel ranges, with comparable speeds.

An explanatory article — "Flux-Injection Method Brings Economies of Oxyacetylene Flame Cutting to Stainless Steels" — is available. For your free copy, write: Dept. MD-6142 Air Reduction, 60 East 42nd St., New York 17, N. Y. In Texas: Magnolia Airco Gas Products Co., Houston 1, Texas. Represented internationally by Airco Export Corporation.

AIRCO **AIR REDUCTION**

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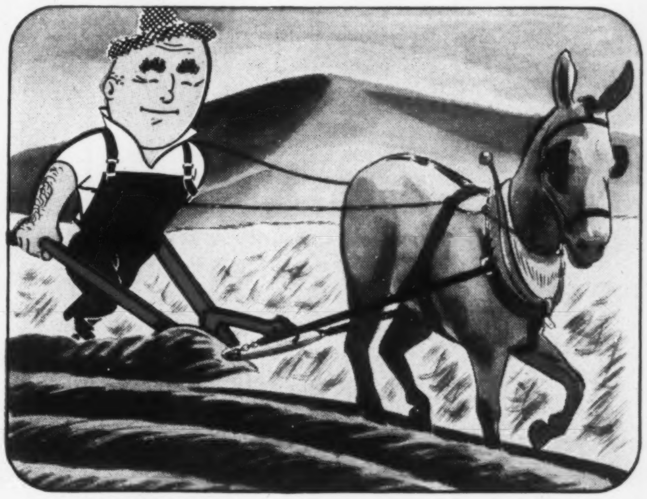
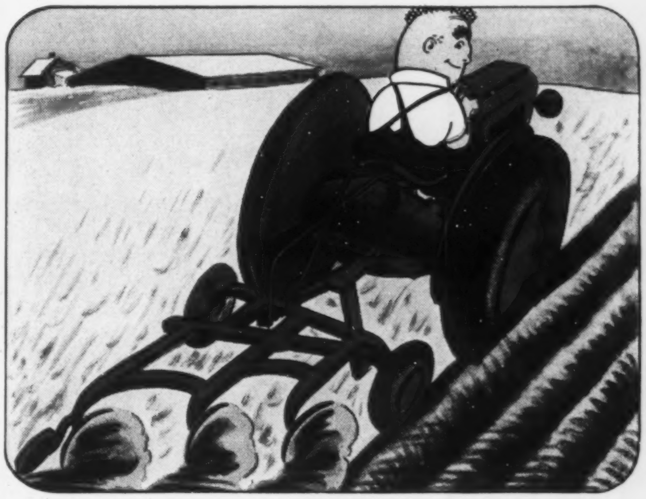
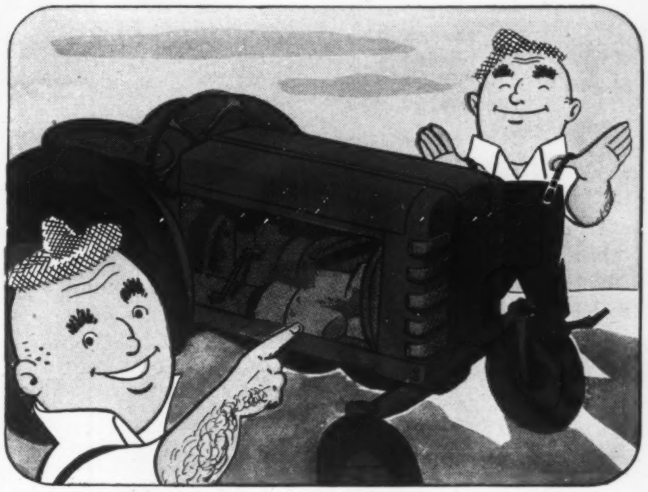


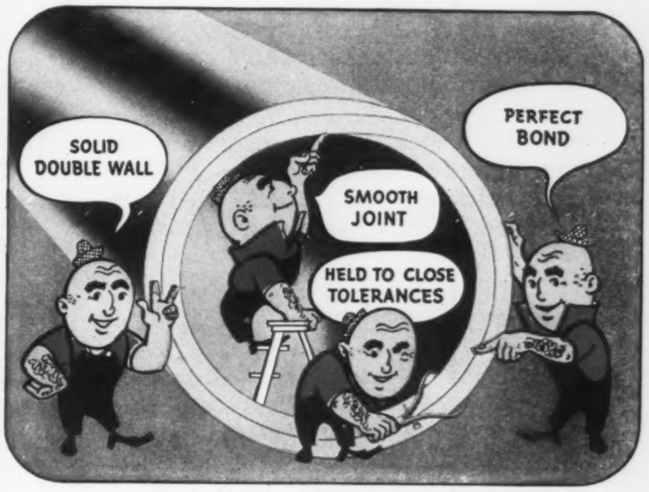
1. TIME WAS when plowing the standard 40 acres with a mule was work enough for any farmer. It required a strong back, sunrise-to-sunset hours in the fields and lots of patience. In contrast, farmers today can handle much larger fields with much less effort.



2. KEY TO THEIR present-day capacity is the remarkable new farming equipment—like super-efficient tractors that make plowing almost as easy as driving a car. But tractors weren't always so capable. Much of their efficiency can be traced to features like Bundyweld* Tubing.



3. IN LINES for carrying fuel, vacuums, oil and hydraulic fluids, Bundyweld gives highest efficiency to tractors. Bundyweld is important in hundreds of other products, too—in modern gas ranges, in freezer units and other cooling devices, in motor vehicles and in many other applications.



4. BUNDYWELD is different from other tubing. A single strip of basic metal, coated with a bonding metal, is rolled continuously twice laterally into tubular form, then metallurgically bonded by intense heat—carefully controlled—to form a solid, double wall tube, held to close dimensions.

5. HUNDREDS of engineers and product designers consistently specify Bundyweld. Chances are, Bundyweld can give better answers to your tubing problems, too. Why not let Bundy Research and Engineering Departments look over your product and see? Available in steel, Monel and nickel. *Bundy Tubing Company, Detroit 14, Michigan.*

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Topics

ALL-MAGNESIUM structure for the control surfaces on the Beechcraft "Bonanza" plane effects a 9 per cent weight reduction when compared with the use of wood for the same structures. The six surfaces formerly required a total of 439 parts whereas with magnesium only 102 parts are required with consequent saving in tooling.

PRODUCTION of an infinite variety of new chemicals has become possible through the development of beta-propiolactone, experimentally produced by B. F. Goodrich Chemical Co. The new organic material promises to open up better and cheaper reaction methods of producing many basic materials already used in the chemical and plastics industries.

MOLYBDENUM is now being produced in various shapes and sizes by a technique developed by Westinghouse research engineers. Blocks weighing 250 pounds have been made. Because the material's melting point is above 4750 F it may find new uses in rockets, jet engines and gas turbines.

DIAMONDS, being highly sensitive to gamma rays, may be used to detect radiation in the same way as a Geiger-Mueller counter. If placed in a strong electric field they initiate sharp electrical pulses when gamma radiation is absorbed. The diamond is clamped between two electrodes maintained at a difference in potential of about 1000 volts. Gamma radiations produce current pulses across the electrodes and may be counted by conventional methods.

HIGH-TEMPERATURE ceramic glazes increase the life of combustion-chamber liners and turbine buckets in aircraft jet turbines, according to the General Electric Co. High melting glass is used successfully when the fuel is kerosene. For gasolines containing lead, a high refractory coating such as magnesia is employed. When the liner is a ceramic tube, alumina has been found to be one of the few materials with required refractory properties.

TREATMENT of polystyrene plastics with Logoquant, applied either by spraying or dipping without curing at high temperatures, makes the plastics 18 per cent more resistant to marring. The new process, developed by Bjorksten Research Laboratories allows the use of polystyrene for applications previously requiring plastics materials costing two to three times as much.

CHROMIZING, a process for diffusing chromium from a volatile chromium compound into steel to improve the surface properties of the metal, is described in a report by investigators for the British Intelligence Objectives Subcommittee investigating German wartime developments. The report is on sale by the Office of Technical Services, Department of Commerce.

FRICTION is no longer an industrial bugaboo, according to William L. Batt, president of SKF Industries Inc. Better metals, better oils and better bearings have reduced friction to the status of a minor annoyance. Many standard machines now operate accurately at speeds up to 75,000 rpm in everyday shop practice.

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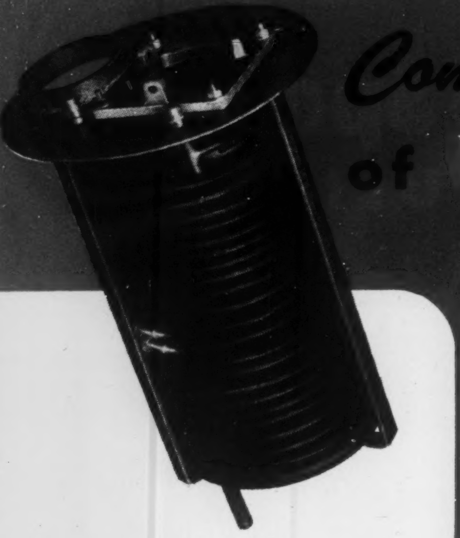

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MACHINE DESIGN

How Much Will the New Machine Cost

By Curt Nyberg

Chief Estimating Engineer
Barnes & Reinecke, Inc.
Chicago

TODAY, MORE than ever, due to the need for combating ever-rising labor costs, manufacturers are becoming new machine minded. Machines now in service are being constantly replaced with more modern machines which operate at higher speeds. Hardly any branch of industry has remained untouched and ingenious devices undreamed of a decade ago today are accepted standards. Whenever a demand is evidenced for higher production, improved service, or reduced costs a new machine is invariably indicated, giving rise to the question, "How much will the new machine cost?"

In answering this question, it is important to recognize at the outset that different designers have different ideas as to how a machine should be designed. Yet, the final result, functionally, will be the same. With this fact in mind, it is interesting to know how an estimator arrives at the cost of a machine that has never before been built.

The estimator invariably is a person who has "been around", knows shop procedure thoroughly, has had years of experience in machine designing and has the vision necessary to conceive a new design. To him all machines to be designed and engineered, regardless of type, have one thing in common, i.e., all perform predetermined operations which, put in their proper

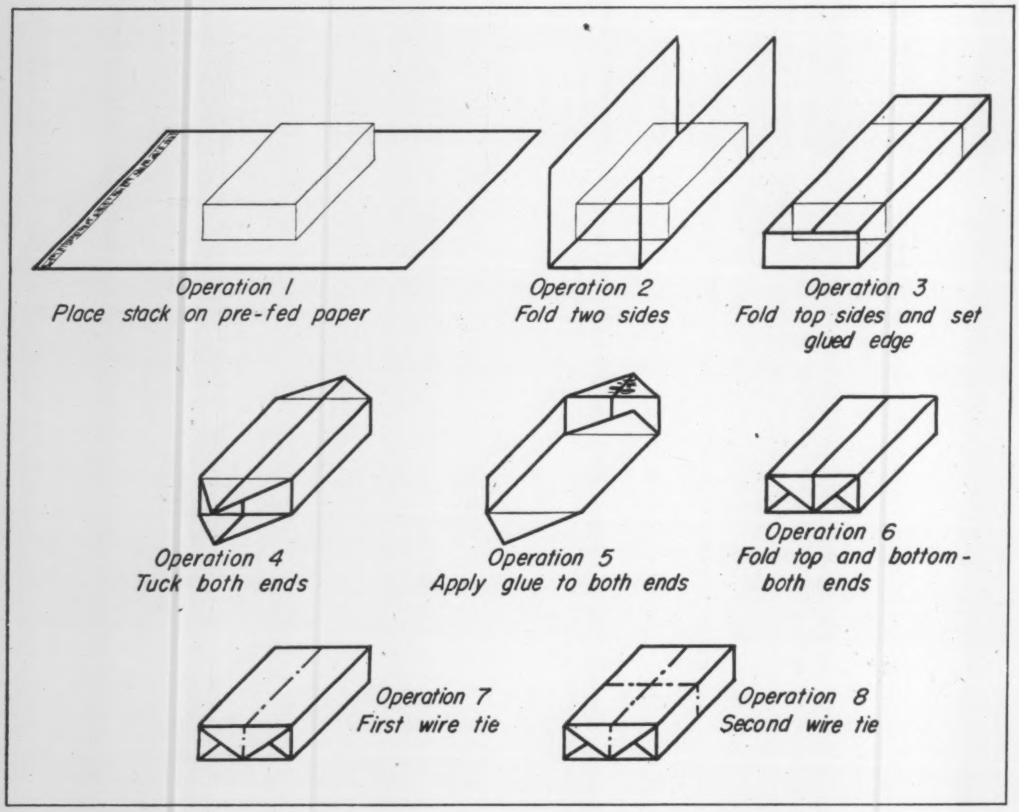


Fig. 1 — Sketches depicting step-by-step functional results required of machine, keyed in with mechanisms schematic (Fig. 2) are helpful first step in estimating engineering and design cost

sequence, must perform the desired service, produce the part, package, assembly, etc. In some cases two or more operations may be combined. The entire anticipated performance of a machine can be classified as operations 1, 2, etc. Each operation is performed by an individual unit, commonly known as a subassembly. Theoretically, there are as many subassemblies as there are operations. Add to this the main drive and the connecting driving links and the machine is practically built. The breakdown into subassemblies gives the estimator his first clue.

Influence of Anticipated Production

However, this short analysis is by no means sufficient to arrive at a cost figure. Anticipated production is also a big factor to consider. The question arises, "How much time is allotted to complete all operations?" In other words, "What is the time cycle of the machine going to be?" To find the answer, the estimator charts the cycle and determines if all operations can or cannot be performed within a given time limit. If the latter should be the case and since the production rate is not likely to change, he must then resort to other alternatives. He carefully studies the pros and cons of a multiple-run versus several machines. While it may be entirely possible to build a multiple-run machine for less money, he must also consider the expected complexity as well as future maintenance and care. Consequently, it is the type of machine he is estimating that gives him the second clue.

It is invariably required that new machines incorporate the latest technical improvements such as electronic controls, electric eyes, mechanical hopper feeds and the like. While all the aforesaid items have proved themselves successful in the past, the estimator often finds himself confronted with the problem, "Will it work in this case?" Since the result often is unpredictable he must make allowances for both time and material needed in conducting experiments to prove a principle right or wrong. The amount of research to be done serves as a third clue. Number of hours needed for the research can be determined only by the experience of the estimator and his evaluation of the complexity of the job to be done.

With these three clues at his disposal the estimator sketches the subassemblies necessary to perform the various operations. These individual units are placed schematically and the drives added. Thus an outline of the assembly is born. The estimator then prepares a written explanation of the operations shown in his sketches, which later is used by the project engineer and the designer.

In designing a new machine utmost care and precaution must be exercised. The entire project must be well conceived and executed along scientific lines. There can be no wishful thinking. Time must be allowed for consultations with the project engineer, as well as the designer. This consultation quite often is attended by top management personnel of the company or department which will use the machine and may be called the "Objective Meeting". Time allowable for this objective meeting depends entirely upon the size of the project. The objective meeting's primary purpose is to reconstruct a mental picture of the machine to be designed. The prospective user usually makes known all of the conditions existing in the plant that materially affect the design of the new machine. He also analyzes and discusses the project as interpreted by the estimator, so that any points overlooked or misunderstood can be clarified before the actual designing begins.

It is customary, when designing a new machine, to allow some time for preliminary engineering. This time varies with the size of the project and may be calculated to require anywhere between fifty and two hundred hours. The engineer uses this time to make a schematic layout of the proposed project and after receiving approval on it he is ready for the final design which includes all subassemblies and drives.

How does the estimator know the time required to design the machine? There is only one answer. He makes a careful analysis of the sketches he has prepared, formulated by the first three clues, and since he has worked on the "board" himself, he relies on his own experience and evaluates the time necessary to complete the actual finished drawings, accordingly. His evaluation includes the designing, the drawing of the assembly and subassemblies, the detail parts to be manufactured, and a bill of material. Since most machines are equipped with a number of standard parts called for in a bill of material or specification sheet, and for which no drawings are made, the estimator gives his attention to the parts to be manufactured and arrives at the detailing time, which invariably amounts to fifty to seventy-five per cent of the design time.

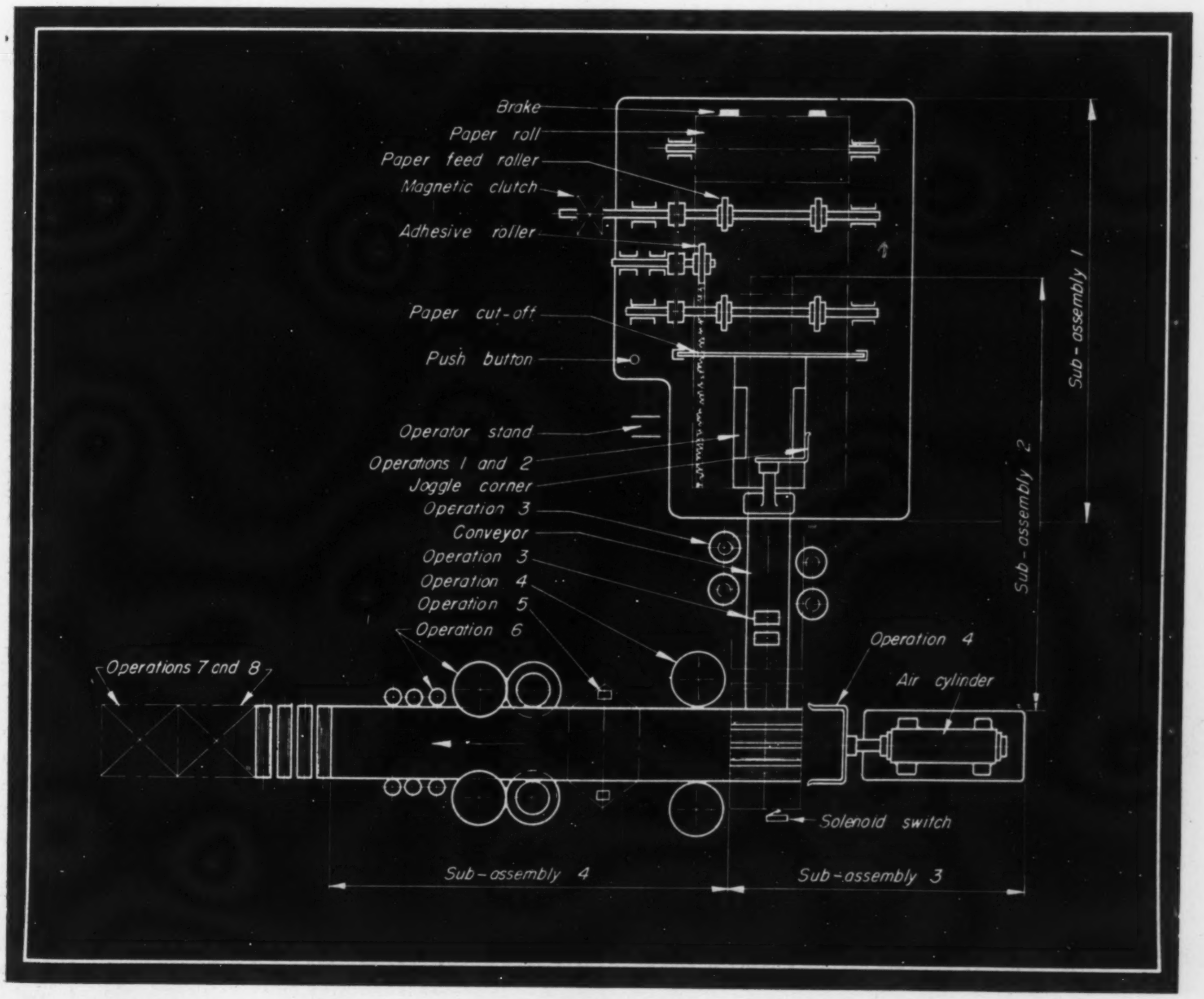
Allowing for Uncertainties

The estimator cannot consider his job finished at this point, due to the uncertainties that are involved in the invention and development of a new machine. Normally, completed engineering drawings are turned over to the checking department and the estimator allows fifteen per cent of the total designing and detailing time for checking and about three per cent for revisions and corrections.

In each case, step, or clue, where the estimator has determined an approximate time factor for a particular phase of the engineering of the project, the breakdown of time factors are multiplied by their respective rates. The total cost of engineering is a summation of the time × rate factors.

How much will it cost to build the machine, now that the engineering cost has been approximated? Since it is possible to establish general clues regard-

Fig. 2—Below—Schematic breakdown by subassemblies of machine is valuable guide in estimating


Brake
Paper roll
Paper feed roller
Magnetic clutch
Adhesive roller
Paper cut-off
Push button
Operator stand
Operations 1 and 2
Joggle corner
Operation 3
Conveyor
Operation 3
Operation 4
Operation 5
Operation 6
Operations 7 and 8
Operation 4
Air cylinder
Solenoid switch
Sub-assembly 1
Sub-assembly 2
Sub-assembly 3
Sub-assembly 4

Type of Work	Ass'bly	SA (No.)	Time (hrs.)	Rate ($)	Am't ($)	Total ($)
Preliminaries		1	10	2.50	25.00	
		2	10	2.50	25.00	
		3	10	2,50	25.00	
		4	10	2.50	25.00	
	A		60	2.50	150.00	250.00
Objective Meeting			10	2.50	25.00	25.00
Design		1	100	2.50	250.00	
		2	20	2.50	50.00	
		3	30	2.50	75.00	
		4	40	2.50	100.00	
	A		60	2.50	150.00	625.00
Design Revision		1	6	2.50	15.00	
		2	2	2.50	5.00	
		3	2	2.50	5.00	
		4	2	2.50	5.00	
	A		4	2.50	10.00	40.00
Detail		1	180	1.80	324.00	
		2	30	1.80	54.00	
		3	50	1.80	90.00	
		4	70	1.80	126.00	594.00
B/M		1	20	1.80	36.00	
		2	5	1.80	9.00	
		3	5	1.80	9.00	
		4	5	1.80	9.00	
	A		5	1.80	9.00	72.00
Checking		1	40	2.50	100.00	
		2	8	2.50	20.00	
		3	12	2.50	30.00	
		4	16	2.50	40.00	
	A		10	2.50	25.00	215.00
Checking Revisions		1	4	1.80	7.20	
		2	1	1.80	1.80	
		3	1	1.80	1.80	
		4	2	1.80	3.60	
	A		2	1.80	3.60	18.00
				Grand Total		1839.00
				Contingencies 10%		184.00
						2023.00
				Overhead 100%		2023.00
						4046.00
				Profit 5%		202.00
				Engineering Cost		4248.00

Fig. 3—Estimated-cost breakdown of planning, engineering and drafting the machine schematically sketched in Fig. 2

ing engineering, the same can be done for building.

Let's take a look at the surroundings where the machine will be put to work. Perhaps the machine will be used in a feed packing plant, where dust plays an important role. Or, it may be a contrivance working near lacquer or chemical fumes. Such conditions automatically make solenoids undesirable. Mechanical linkage, air or hydraulic devices under the same conditions would be better. Then too, enclosed or explosion-proof motors would have to be used. Chains would have to be nonferrous, to eliminate all possibilities of producing sparks. State laws have to be observed and adequate safety devices provided. Environment and purpose will indicate many of the materials to be used and give the first clue of the building cost.

Precision costs money—the more precision, the more money. The estimator has to determine the class of work necessary to make the machine perform without adding unnecessary expenses. Extremely high precision sometimes called for may double or even triple the cost of a unit having commercial tolerances. Precision, tolerances, and workmanship can be called the second clue.

Estimating Standard Items

Even though a machine may be special, a number of standard items will always be present. It stands to reason that the estimator may be at a total loss where accurate sizes are concerned. Neither is he interested if a shaft or bearing is to be 2 inches in diameter, or 2½ inches. He knows, however, what type of bearing would be best, how many gears and sprockets may be required and approximately how much chain will be needed. Clutches, motors and speed reducers may be other standard items, and while he may not be able to estimate the true cost, he will strike an approximate figure. Standard items, then, supply the third clue.

While a new machine may be designed as carefully as possible, there never has been and there never will be one which didn't need final adjustments and refinements during and after assembly. Parts have to be brought into cycle position and locked, gear backlashes have to be eliminated, taper pin holes have to be drilled and reamed in assembly. An air piston may prove too small and require replacement by a larger one. A vacuum line may not release in time, requiring that the port be cut larger. These items come under the heading of " contingencies" and probably never can be calculated in dollars and cents. Nevertheless they do provide another clue for the estimator. All manufactured parts and manufacturing operations are, of course, figured on a time and rate basis.

While all the aforementioned items will undoubtedly help considerably in the establishment of a cost figure, it still is desirable to draw from the knowledge of past experiences with similar machines. It is well to bear in mind that an estimate is only an approximate figure that has been established by clues only. The true building cost of any new machine can be given only after the last key has been set and the trial run proved satisfactory.

In order to give a more vivid picture of estimating, the author has selected a magazine wrapping machine problem to illustrate how the designing and building costs were established in accordance with the techniques outlined in the foregoing. The following requirements are typical of those which might be received in a request for quotation on the engineering and building of this type of machine:

1. Wrap magazines for postal shipment
2. Size of stack to be wrapped, 8½ x 11 x 6 inches
3. Use fifty-pound Kraft paper from roll
4. Production required, five per minute.
5. Magazines stacked to be hand loaded
6. Form gift-type package
7. Glue top edge
8. Glue both ends
9. Wire tie in both directions

The estimator approached this problem by asking himself, "What kind of a package is wanted?" Knowing that the client's specification sheet specifically mentioned a gift-type package, the estimator proceeded to make sketches which schematically demonstrated how the package was to be made. Using this procedure, it became obvious to the estimator that eight operations were needed to make the complete package, *Fig.* 1. Next, the estimator was concerned with "How to do it" (how to perform these operations). Before beginning the preparation of an outline sketch of the machine, it was necessary to give consideration to the following points, which are pertinent to the problem.

The Breakdown into Subassemblies

Referring to Operation 1, shown in *Fig.* 1, it is necessary to have the paper cut to a proper length and glue applied to one edge of the paper as it is fed from the roll. Then, a cut-off mechanism is needed. A bundle of magazines is placed manually on the sheet of paper, which in turn is on a moving platform. In order to complete Operation 2, the platform should recede and carry the magazines and paper to side ploughs which fold the two sides ninety degrees and place the package on a constant speed conveyor belt. While the paper and platform descend with the magazines, a new sheet enters for reloading the first operation. The package-carrying conveyor transports the partly wrapped package to a number of folding rollers, completing the wrap-around of the sides (Operation 3). Simultaneously, the glued edge passes through a pressure roller, completing Operation 3. The partly wrapped package is then brought to a roller platform equipped with a solenoid air valve control and an air cylinder. This platform serves as a transfer station. As the opened edge comes in contact with the solenoid control switch it closes the circuit, forcing the air valve to open and release pressure into the air cylinder, which pushes the two ends inwardly by means of a fork. At the same time, the two opposite ends are pushed against two rollers, completing the end folds for Operation 4. In the process of folding the ends the package is ejected to another constant-speed conveyor. Glue rollers placed on each side of the moving conveyor apply the adhesive on the lower side of the upper flap, conforming with Operation 5. With its application of glue, the package travels through another series of folding rollers, completing the wrapping envelope, leaving the final sealing to vertically arranged pressure rollers, Operation 6. The package is then moved to a take-off platform, ready for wire binding. The remaining operations (7 and 8) can be completed by means of two standard wire-tying machines.

Having determined the sequence and number of operations, the estimator determines the number of subassemblies needed to make up the final machine. He then is ready to make a general outline sketch of the same, illustrating the operations, the subassemblies and his conception of the mechanisms needed to perform the work, *Fig.* 2.

Type of Work	Ass'bly	SA (No.)	Time (hrs.)	Rate ($)	Am't ($)	Total ($)
Shop Time		1	600	2.00	1200.00	
		2	200	2.00	400.00	
		3	100	2.00	200.00	
		4	300	2.00	600.00	2400.00
Total Assembly	A		100	2.00	200.00	200.00
Corrections		1	40	2.00	80.00	
		2	15	2.00	30.00	
		3	10	2.00	20.00	
		4	25	2.00	50.00	180.00
Trial Run	A		10	2.00	20.00	20.00
Painting	A		10	2.00	20.00	20.00
Crating	A		20	2.00	40.00	40.00
				Grand Total		2860.00
				Contingencies, 10%		286.00
						3146.00
				Overhead 90%		2831.00
						5977.00
				Material Handling (From Prepared List)		1260.00
						6237.00
				Profit 5%		312.00
				Building Cost		6549.00

Fig. 4—Breakdown of estimated building costs itemizes operations on subassemblies along with respective time and rate factors

Note that the estimator, concluding that the magazine wrapping machine will consist of four subassemblies, makes a breakdown of the time factors, *Fig.* 3, for subassemblies 1, 2, 3 and 4 in every phase of the engineering. The time factors are multiplied by their rates and approximate costs are thus established.

An allowance of ten per cent is made for contingencies, overhead is figured at one hundred per cent and a profit of five per cent is added, which make up the approximate total engineering cost. The same procedure is followed in estimating building costs.

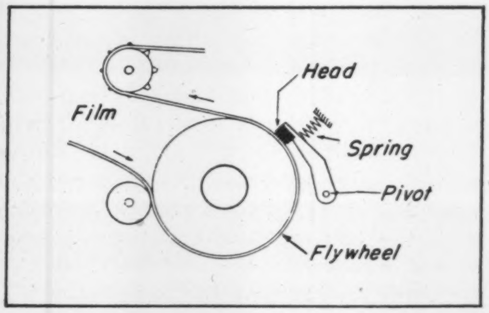
It is well worth repeating that the estimated cost of engineering and building a new machine is, at best, only an approximate figure established by clues. The true cost can be given only when the last key has been set, and the trial run has proved satisfactory.

Scanning THE FIELD for Ideas

Magnetic sound track on motion-picture films gives promise of being a much sought solution for the home movie photographer as well as for the professional. Conventional systems as far as the amateur is concerned are too expensive, inflexible and often give poor results. Illustrated below are a magnetic head on a movie projector and a schematic of the system as developed at the Armour Research Foundation. One achievement that makes it possible to record quality sound at the low film speeds used on 16 and 8-millimeter work is a special high coercive magnetic material which can be bonded into the film stock.

Measurements of magnetic properties indicate that a coercive force of 350 oersteds and a remnance of 500 gausses or more can be obtained in the finished product. These characteristics are obtainable with magnetizing fields of 1000 or below, thus the record can be erased readily. The new material has a fine grain size of one micron or less. It is not affected by photographic solutions, so that magnetic sound can be recorded simultaneously with the picture or can be put on afterward. Tracks have been coated 0.045-inch wide and 0.0005-inch thick. Even though coated on one edge of the film, the track does not affect reeling. Another track may be coated on the other edge, however, for special purposes or if desired a dummy track may be used to provide uniform thickness for large reels

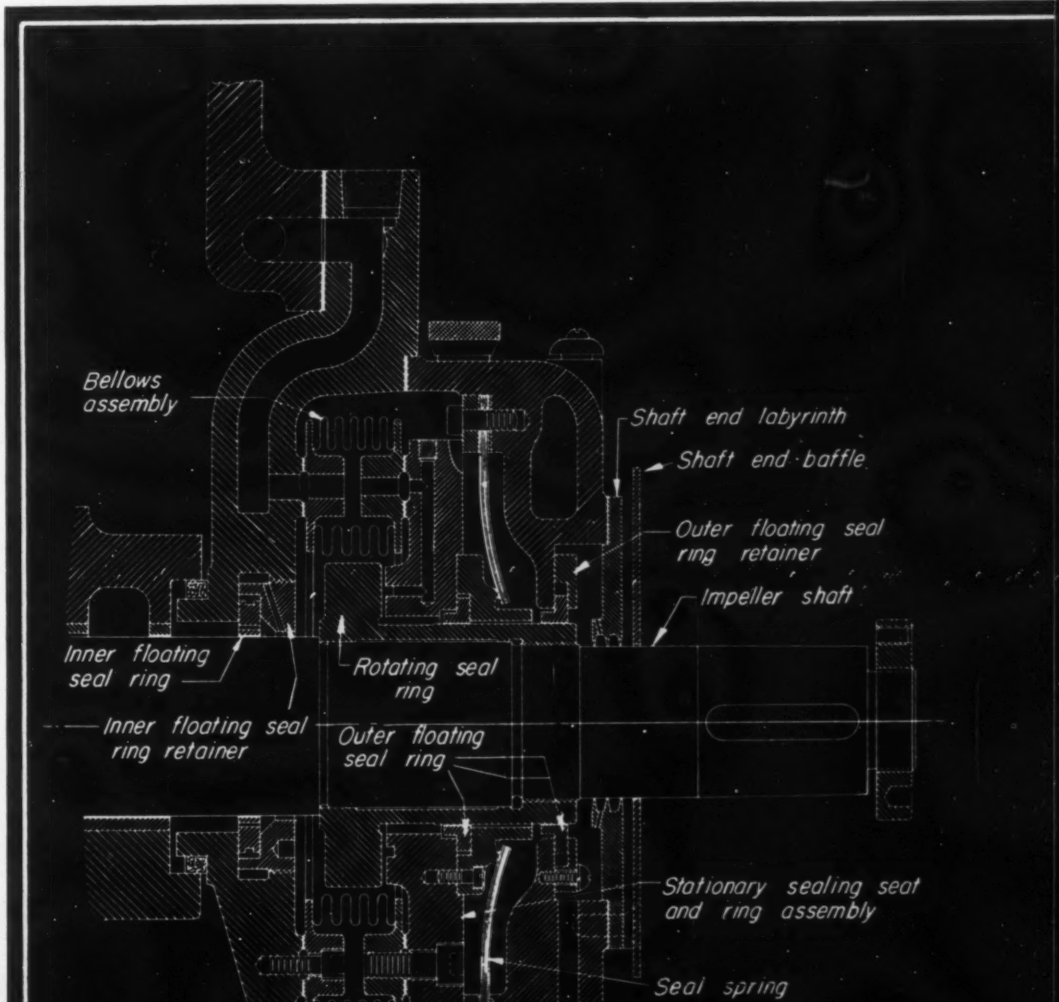
The magnetic head is spring pressed against the film while it rides on the flywheel stabilizer. Such a head can be added to conventional projectors, but the steadiness of the recorded signal will, of course, depend on the quality of the mechanical system. Mass of the head is kept small so that the necessary spring pressure to insure contact with the film may be very light. Because low pressures are necessary, wear problems are minimized.



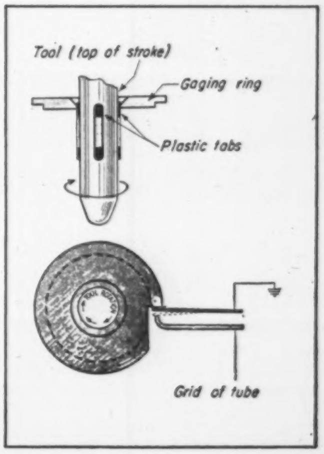
Seal mechanism, illustrated in section on next page, has made the use of centrifugal compressors practical for the refrigeration field. Developed by the Carrier Corp. the seal is formed between a rotating seal ring, which is vacuum fitted against a shoulder on the shaft, and a stationary sealing seat attached to the seal housing through a bellows assembly. Faces on these seats are carefully formed to make a vacuum-tight joint when in contact on shut-down. To effect this seal on shut-down, a seal spring moves the stationary seat to contact the rotating seat.

Between the hub of the stationary sealing seat and the hub of the rotating sealing seat is located a floating ring. An oil reservoir is attached to the compressor housing above the seal, supplying oil to keep the seal faces flooded during shut-down periods. An orifice between filter chamber and reservoir restricts flow to the reservoir during starting, if the reservoir has drained during shut-down. By this means, full oil supply is assured for the seal on starting.

When the compressor starts up, oil is pumped to the interior of the bellows assembly. This pressure expands the bellows, moving the stationary sealing seat against the pressure of the spring to a stop on the seal housing cover, leaving a space between the faces of this seat and the rotating seat on the shaft. Oil in the bellows passes through drilled passages to an oil groove cut eccentrically in the face of the stationary sealing seat. From this groove the oil passes across the outer section of the face of the stationary sealing seat and into the space between the shaft and the bellows assembly. Oil flow from this space is prevented by a floating ring called the inner floating ring. Also the oil flows across the inner section of the face of the sealing seat and through the clearance between the rotating sealing seat hub and stationary sealing seat. This flow is restricted by the close clearance of the floating ring between these two parts as well as by the outer floating ring between the seal housing cover and rotating seal hub. Thus during operation the oil seals the shaft against inward leakage of air and obviates metal to metal contact.

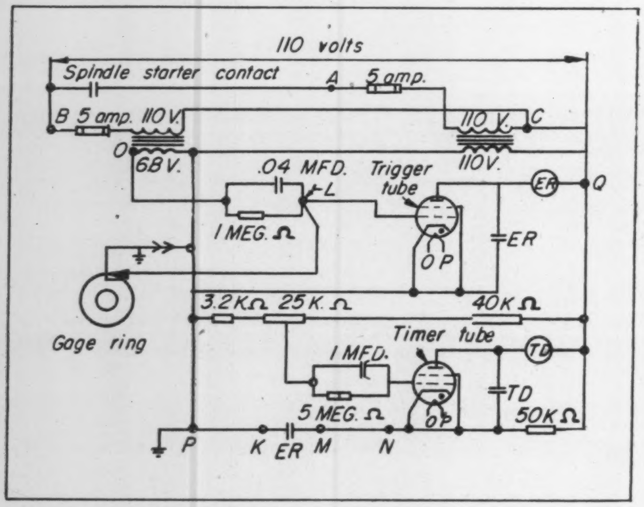

Bellows assembly
Shaft end labyrinth
Shaft end baffle
Outer floating seal ring retainer
Impeller shaft
Inner floating seal ring
Rotating seal ring
Inner floating seal ring retainer
Outer floating seal ring
Stationary sealing seat and ring assembly
Seal spring
Seal housing cover
Seal housing

Sizing control, right, for automatic honing of bores makes it possible to hold bore-to-bore size within 0.0003-inch in production, measurement being obtained from plastics tabs on the upper ends of the stoneholders. Developed by Micromatic Hone Corp., the control utilizes a gaging ring with a carbide insert so located that only the plastics


Tool (top of stroke)
Gaging ring
Plastic tabs
Grid of tube

tabs enter the ring at the top of each stroke. Since the tabs wear with the stone, they become an accurate indication of bore size. The ring is mounted so that, when the bore reaches size the frictional drag of the tabs rotates the ring sufficiently to ground the grid of a trigger tube as shown in the sketch on the previous page and the schematic circuit below.

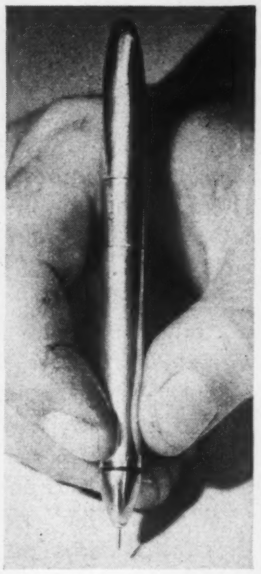
This action removes the blocking potential on the grid, thereby allowing the tube to fire. With



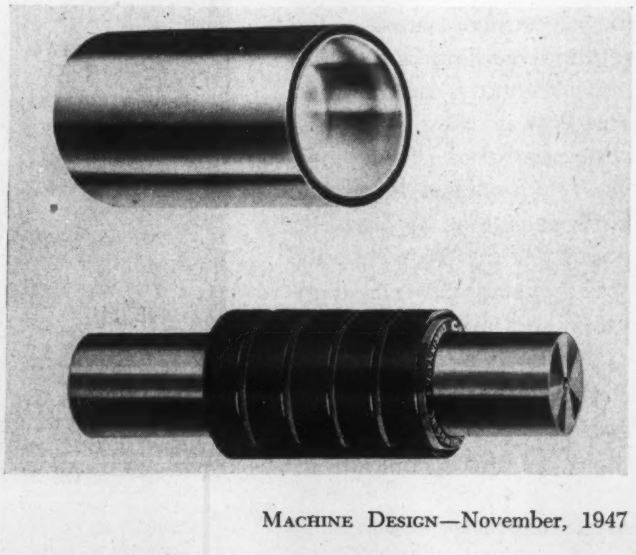
the flow of electrons no longer blocked, relay ER is energized closing the ER contacts. One contact energizes a solenoid that shifts a spool, stopping the expansion of the tool. The other contact grounds the cathode of a timer tube. Unlike the trigger tube the timer tube does not fire immediately. There is a predetermined delay governed by a charge on a 1-mfd condenser. This condenser loses its charge through a 5-megohm resister. Then the grid of the timer tube no longer blocks the flow of electrons and the tube fires. Relay TD is picked up, energizing a solenoid which causes collapse and withdrawal of the tool from the bore.

Drafting pen, at right above, is a capillary-action instrument developed at Beech Aircraft Corp. for its engineering draftsmen. Extending from the forward end of the barrel is a short length of fine tubing which culminates in a semitoroidal-shaped sapphire point. The ink, contained in the barrel, is held at the point by surface tension and will not flow until contact is made with the drawing surface. Contact fractures the tension bubble and permits the fluid to be drawn out as the point is moved over the surface. A variety of interchangeable points permits different types of lines varying from a few thousandths of an inch to heavy, wide lines. To allow maximum control over the flow of the liquid, a screw type top actuates a plunger inside the barrel and either forces more ink out of the pen for heavy lines or releases pressure for fine line.

Fluid used is a quick-drying lacquer with adhesive properties and a viscosity that precludes gravity flow. Errors are readily corrected, and the lacquer does not flow under triangles.



Corrosion-resistant bearings, below, are designed to operate in almost all liquids. The bearing itself is a special, extra hard, acid-resistant porcelain enamel on steel backing and the journal is a series of synthetic-rubber sleeves fitted over the shaft. Field tests over a period of six years indicate that they will outwear common rubber bearings with Monel sleeves about 5:1, and oil-lubricated bearings about 25:1. The synthetic-rubber journal is self lubricating, revolving against the porcelain with a minimum of wearing friction. The bearing illustrated, designed by Caldwell Glass Bearings Inc., has a journal molded in sections 3/4-inch high and approximately 1/4-inch thick. These sections are stacked to give any desired length. The journal sleeve has a hole smaller than the shaft and, when forced over the shaft, is sufficiently tight to revolve with it. The tubular walls of the porcelain-enameled bearing are approximately 1/4-inch thick and are turned smooth for a press fit into a spider.



Vulcanized Fiber for Machine Parts

By Gerard A. Albert
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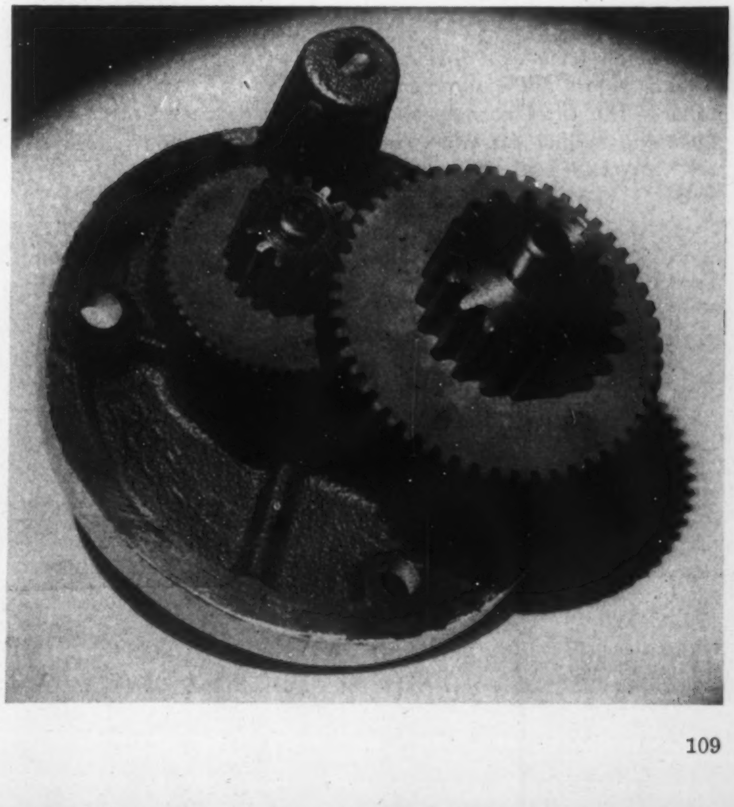
VULCANIZED fiber has been successfully used for machine parts, such as the shuttle of *Fig.* 1, ever since this material was first commercially made in the early 1900's. A converted cotton cellulose, vulcanized fiber is hardened by a chemical which is removed later, leaving a pure, hard, tough, and strong material. Fundamentally, it is made by passing a special chemically reactive cotton paper through a zinc chloride bath, which attacks and gels the surfaces of the individual fibers of the paper, causing them to adhere to each other in the same sheet, as well as to those of adjacent sheets. After passing through the treating bath the plies are pressed together between large cylinders to aid lamination, and then run through a series of water tanks to leach out the zinc chloride, leaving the pure converted cellulose which is dried and calendered or pressed.

CHARACTERISTICS: Vulcanized fiber is a tough, horn-like organic material. The properties that make it extremely useful to the machine designer are its high mechanical strength—particularly impact—good electrical properties, excellent machinability, good formability, high resistance to wear and abrasion, durability, and light weight (one-half the

Fig. 1—Above—Wood shuttle is faced with vulcanized fiber which will not splinter and wears to a high polish

Fig. 2—Below—Vulcanized fiber gears in mesh with steel gears are quiet, shock resistant and have excellent wearing properties



weight of aluminum). Its mechanical properties, when calculated on an equivalent weight basis, are comparable to those of many metals. Fiber does not absorb oils or greases and is not adversely affected by them. Since it is organic, however, its operating temperature must be limited to about 170 F for continuous operation. In TABLE I are listed some properties of vulcanized fiber suitable for use in machines.

FORMS AND COLORS: The standard commercial colors of fiber are red, gray and black, although many other colors are made for special applications. These are: Russet, mahogany, olive, white, walnut, brown, green, canary, blue, purple, orange, etc. Vulcanized fiber is made in only two forms; sheets and tubes. Rods are machined from thick sheets which are made up to 2-inches thick. Tubes range in inside diameter from 3/16 to 7 inches with walls varying from 1/32 to 5/16-inch.

Many Grades Available

Even though there are only four main NEMA grade classifications of vulcanized fiber, there are many subdivisions to each which were developed for special applications. Today about thirty distinct grades of fiber are made. The four standard grades are divided as follows:

A. **Electrical Insulation Fiber:** For electrical insulation purposes in general. Its outstanding characteristics are high strength, good bending qualities and high dielectric strength. It is produced up to about ⅛-inch in thickness. If thicker insulation is required, mechanical and electrical fiber is used. Thin insulation often is called fish paper.

B. **Mechanical and Electrical Fiber:** For general mechanical and electrical purposes covering a wide range of applications. Often referred to as Commercial Fiber.

C. **Bone Fiber:** A harder grade of fiber for mechanical and electrical use.

D. **Trunk Fiber:** Especially adapted for trunks, suit cases, baskets, etc.

ELECTRICAL PROPERTIES: Vulcanized fiber has good dielectric strength and other electrical properties but its outstanding electrical property is its ability to resist surface carbonization when subjected to live arcs. It will not "track" due to arcs or leakage currents and this property makes it invaluable as the barrel material for the familiar cartridge fuse and other applications around or near electric arcs.

MACHINABILITY: Probably the chief reason why vulcanized fiber has become a staple material in all

Fig. 3—Right—Screw cap employs vulcanized fiber washer which resiliently compresses to produce an effective airtight seal

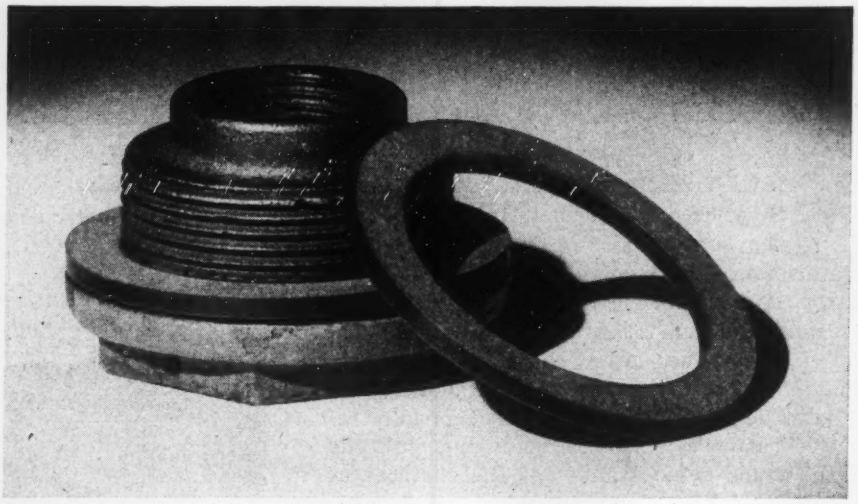
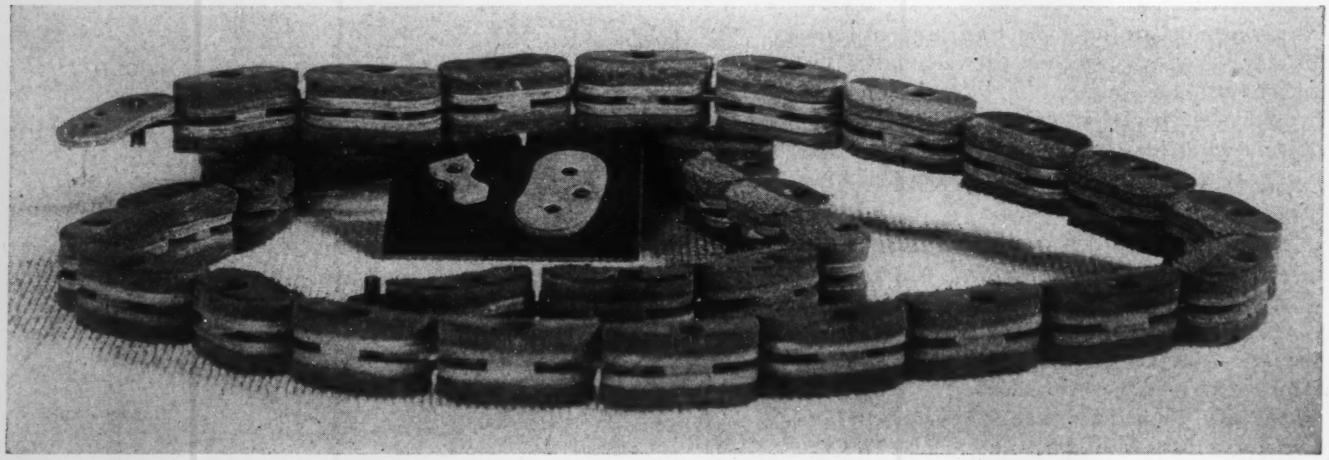


Fig. 4—Below—Link-type drive belt has punched fiber links surfaced with leather. The fiber carries the load, while the leather provides traction



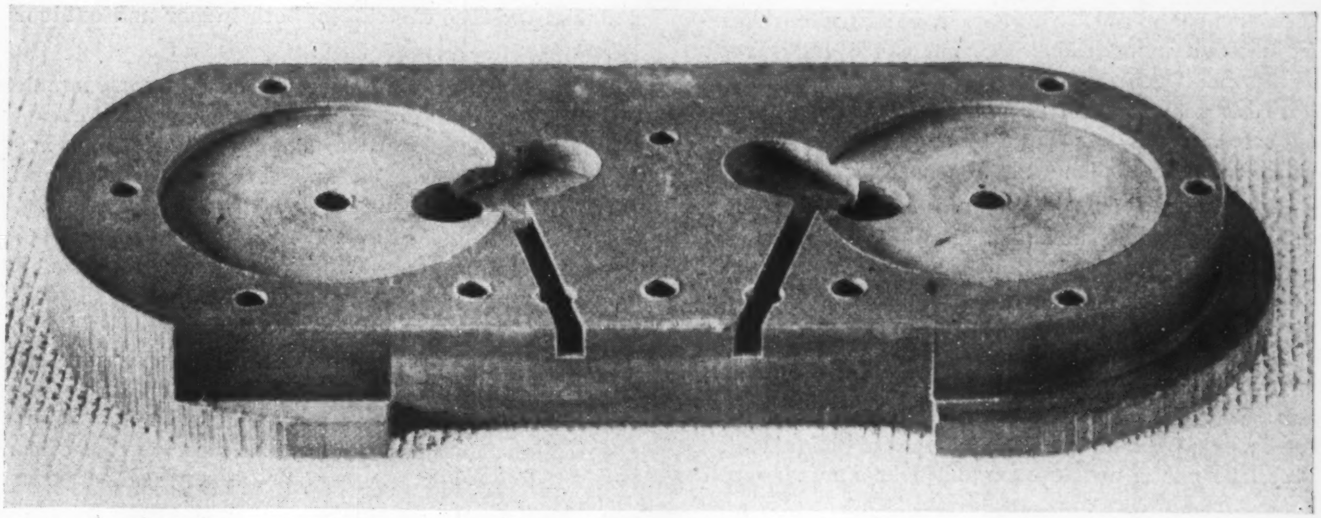
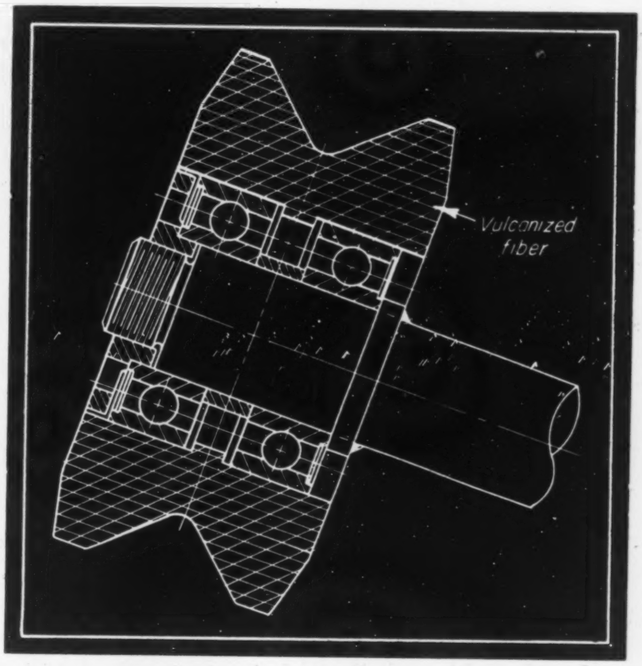


Fig. 5—Above—Vulcanized fiber bumping block of pneumatic conveyor system stands up under constant pounding

Fig. 6—Below—Vulcanized fiber is excellent material for sheave wheels used in cable systems



industries is its exceptional machining characteristics. It can be sawed, sheared, drilled, tapped, milled, turned, threaded, punched, planed, shaped, spun, and shaved with ease. Its machining follows in general the methods used for metals, and standard machining equipment used in both metal and woodworking industries is adaptable for its fabrication.

For shearing, metal squaring shears are adaptable. Fiber ¼-inch thick may be sheared with good edges. Rotary shears will shear or "slit" fiber up to 5/32-inch thick. Band-sawing can be done satisfactorily using high-carbon steel tempered saws. Smooth sawing is done with hollow ground circular saws with no set on the teeth.

Punching is done with standard power-driven presses. Fiber ¼-inch thick can be punched or blanked.

TABLE I

Properties of Vulcanized Fiber Grades Suitable for Machine Parts

Density (gm/cc)	1.0–1.5
Density (lb/cu in.)	0.036–0.054
Tensile Strength (psi)	6.000–12,000
Compressive Strength (psi)	20,000–30,000
Flexural Strength (psi)	12,000–20,000
Shear Strength (psi)	11,000–15,000
Impact Strength, Izod (ft-lb/in. notch)	4–8
Rockwell Hardness	R-60 to R-100
Modulus of Elasticity (psi)	750,000
Dielectric Strength, S.T.. ⅛-in. (volts/mil)	150–250
Thermal Conductivity (Btu/hr/sq ft/°F/in.)	3
Specific Heat (Btu/lb/°F)	0.37

On thick complicated parts, heating the piece materially aids punching. Fiber is available in coil form for use with roll feeding mechanism for high-speed punching. Many small fabricated parts are made on automatic screw machines, lathes and turret lathes, using either high-speed-steel tools or, better yet, carbide-tipped tools.

FORMABILITY: Vulcanized fiber can be formed, bent and drawn. This is accomplished by first softening the fiber by immersion in water maintained at 160 to 210 F, or in a live steam bath.

When removed from the water or steam, the softened fiber is drawn or formed in heated metal forming dies, and held there under pressure until the water is sufficiently evaporated to permit the finished piece to maintain its formed shape and to regain its rigid and tough dry characteristics. The required pressures for forming are low, being in the range of 200 to 500 pounds per square inch on the projected area.

Fiber of all thicknesses can be formed but most commercial parts are made from fiber 1/32 to 3/16-inch thick. This thickness allows good drawing, yet imparts ample strength and rigidity to the finished part.

Applications

FIBER GEARS: Many years ago when design engineers were forced to seek a gear material to use with metal gears to reduce noise, they found an ideal material in vulcanized fiber. Its toughness and resilience offer resistance to the severe starting impact torques encountered by a gear. It has excellent wearing life and in addition, does not cause undue wear on the metal gears with which it meshes, *Fig.* 2.

A fiber gear properly designed as to the right working stresses will have approximately twice the face width of an equivalent metal gear.

Self-Locking Nuts: The red plastic collar in a self-locking nut is vulcanized fiber. These nuts have a recess in them to accommodate the fiber collar in such a way that, as the bolt is threaded into the metal threads of the nut, it impresses its own thread in the fiber collar. When the bolt is removed, the resilient nature of the fiber allows it to release its strains to become an undersize thread, meaning that when the nut is put back it will again grip and hold tightly. Thus, the nut is usable over and over again.

Fiber Gaskets: Vulcanized fiber is an ideal gasket material, chiefly because it can be resiliently depressed by the clamping nut. In addition, it will not disintegrate or deteriorate with age. The gaskets or washers can be stamped and shaved up to ¼-inch in thickness, thus permitting fast and inexpensive fabrication.

There are certain applications that require a softer and more flexible grade than the conventional grades of vulcanized fiber. A special glycerine treatment is given to the fiber to give it these required properties. Illustrated in *Fig.* 3 is a screw cap with flexible vulcanized fiber washer. When the cap is screwed tight the fiber washer, soft and flexible, compresses to give an airtight seal.

Because vulcanized fiber is hygienically clean, it is used extensively for gaskets in milk pasteurizing equipment, for reels for holding sterilized surgical sutures, and in toys.

Motor Insulation: Vulcanized fiber, commercially known as fish paper, is used for insulating the rotor, stator, and field coils of electric motors. This thin material is tough and strong and can be bent and formed, usually by hand, to fit into the slots.

Abrasive Disks: Large quantities of fiber in thicknesses from 0.020 to 0.040-inch are used for making abrasive disks. Some are made by coating the fiber with a phenolic adhesive which firmly bonds to the fiber, after which the abrasive grit is dusted on the wet adhesive, and another coat of adhesive is applied over the grit. When the phenolic binder is baked it holds the grit together as well as to the fiber disk. In this application, the strength of the fiber permits operation at high speeds and, in addition, its flexibility allows flexing each revolution, making possible conformance to corners and contours of the surface being sanded.

Electrical Fuse Cartridges: Unlike other plastics insulating materials, vulcanized fiber, when exposed to an electric arc, will produce a neutral gas, yet will not leave an electrically conductive surface. This is because the cellulose molecule contains a sufficient amount of oxygen to completely unite with the carbon to form carbon monoxide gas. Because of this unique property, coupled with the fact that fiber tubing has exceptional toughness or impact strength and can be satisfactorily threaded, it has become the universal material for fuse cartridges, both indoor and outdoor types.

Textiles: Vulcanized fiber is used in considerable quantities in the textile field because of its exceptional wearing properties, smooth surface, and mechanical toughness. One application is the heads on bobbins. The fiber, when turned, takes on a glass-smooth finish; it will not break when dropped nor become rough when bumped or struck. Further, it resists nail, screw or rivet heads from pulling through even though the bobbin is dropped from great heights.

Another textile use is the facing of wooden shuttles, *Fig.* 1. The fiber is glued to the wooden shuttle using casein or animal glues. With the wood completely covered, the danger of splinters is removed because fiber itself wears with a smooth surface which is absolutely necessary for weaving delicate yarns such as silk and rayon.

Fiber Link-Belt: An interesting application of vulcanized fiber is for the strain members of a link-type driving belt, *Fig.* 4. This belt has links consisting of punched fiber parts, surfaced with leather. Connecting these fiber-leather assemblies are links of metal. The fiber pieces carry the mechanical stresses while the surfacing leather furnishes the necessary traction to the driving wheels. Chief reasons why vulcanized fiber satisfactorily meets the requirements of this application are its stiffness or rigidity, mechanical strength—chiefly tensile and impact—and its excellent wearing properties.

Bumping Block: Sheet fiber 9/16-inch thick, intricately machined, is used for the bumping block in pneumatic conveyor systems (money carriers in department stores). Fiber is employed for this application, *Fig.* 5, because it is highly shock resistant and is not affected by constant pounding. Also it can be machined to the special shapes with grooves, holes, and so on, that are needed for this application.

The applications discussed in the foregoing are representative of many more found throughout all industry. Undoubtedly the future will reveal many others wherein the unique properties of vulcanized fiber can be used to advantage.

Standardized Drafting Practice

LONG-NEEDED standardization of drafting practices in the automotive industries has been undertaken by the Society of Automotive Engineers. Fifteen subcommittees will develop different phases of the project and later will co-ordinate their work.

During World War II, manufacturers were seriously handicapped because drafting practices differed widely not only between companies and industries but also between company divisions and plant departments, with resulting delays, difficulties and misunderstandings. Upon publication as the SAE Standard Automotive Drafting Manual, the data will be made available to the passenger car, truck, bus, engine, tractor, body, equipment, electrical, accessory, and other automotive industries, as well as to engineering schools and colleges.

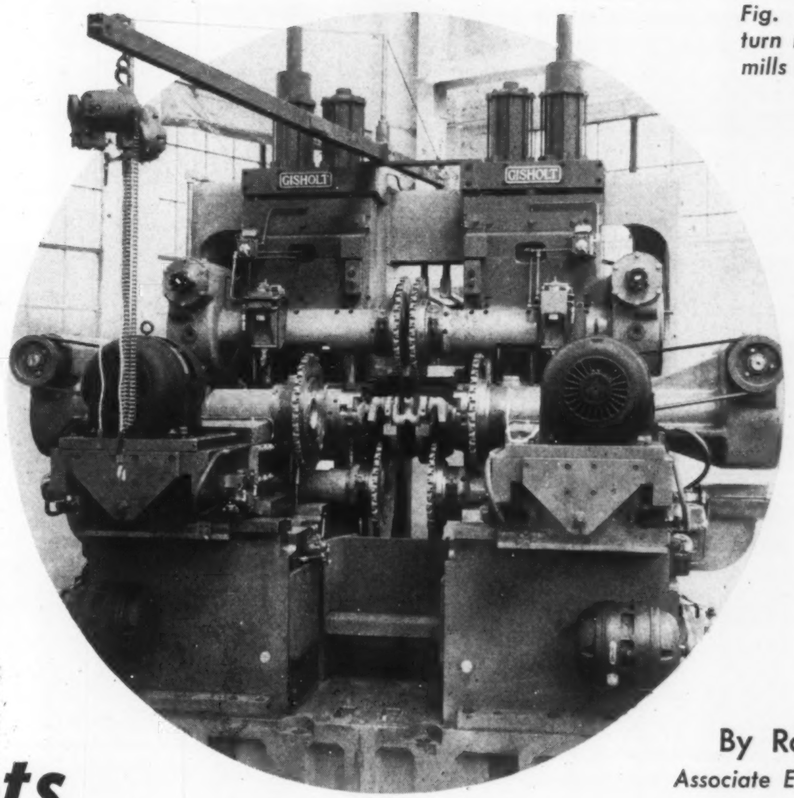


Fig. 1 — Gisholt crankshaft turn miller automatically turn mills pins and cheeks of six-throw crankshafts

Design Aspects of the Machine Tool Show

By Roger W. Bolz
Associate Editor, Machine Design

Up-to-the-minute particulars gleaned from this tremendous exposition provide the key to improved quality, greater production and lower costs

As THE hubub and excitement surrounding the Machine Tool Show fade and die away to faint murmurings, in retrospect the full significance of this educational demonstration to the manufacturing public becomes apparent. The motivating motto "More goods for more people at lower cost" has been given new meaning and purpose. To machine designers in general perhaps the most important factor of the entire Show can be said to rest in "designing for production". Up-to-the-minute knowledge of this great variety of the latest production methods and machines at once provides the key to improved quality, greater production speed and lower costs.

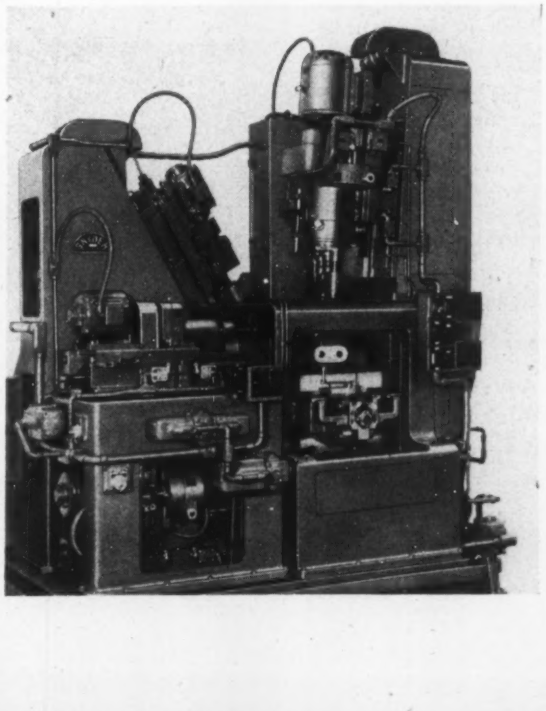


Fig. 2—Snyder special automatic performs drilling, spotfacing and chamfering operations on cast iron intake manifolds at 160 pieces per hour

The feature which undoubtedly stands out foremost is that of increased automaticity of production, *Fig.* 1. With the present trend toward mass output on a greater scale than ever before in history, naturally

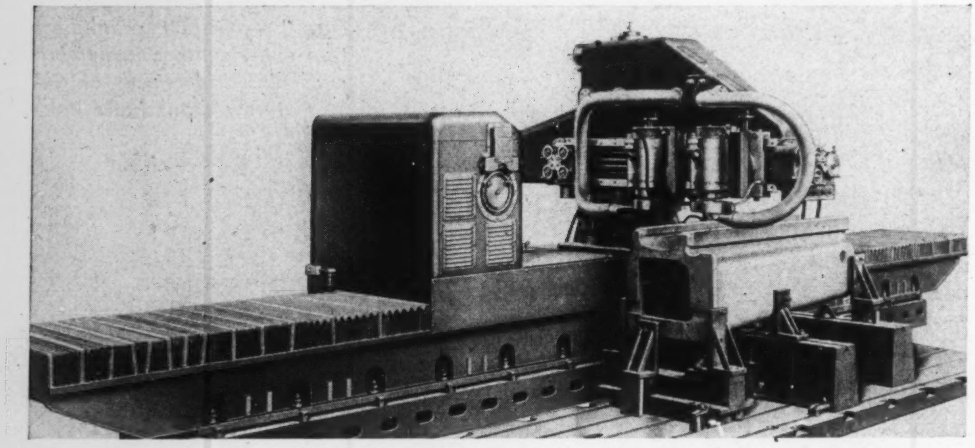
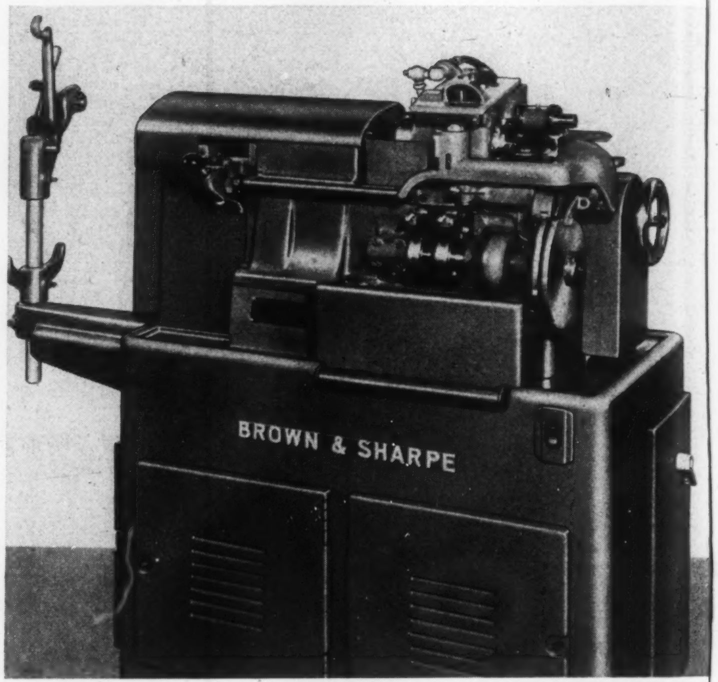


Fig. 3—Left—Giddings & Lewis way grinder produces way surfaces accurate to a few tenths in 20 feet of length

Fig. 4 — Below — Brown & Sharpe automatic pinion machine produces delicate staff and pinion type work to precision limits



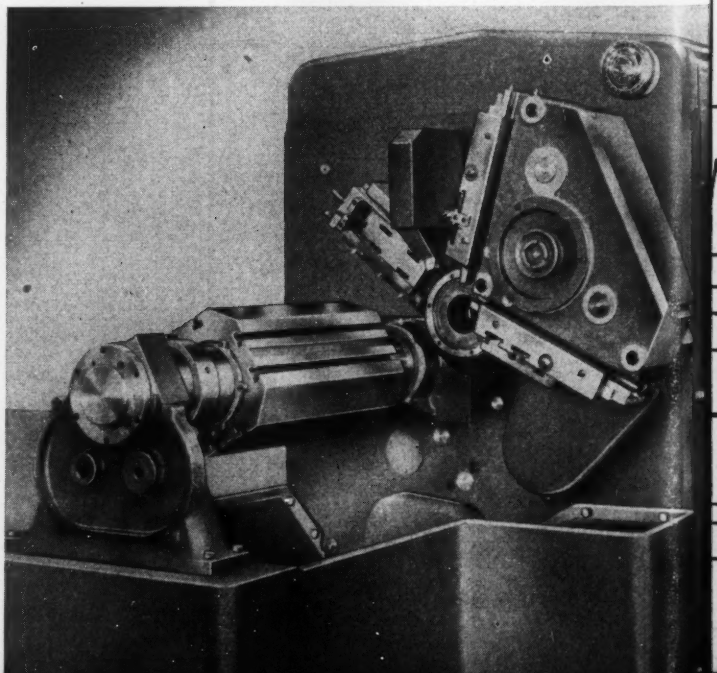
the leading thought of the machine tool designer is that of decreased handling. From the Fay automatic lathe to the Landis Tool crankshaft grinder amazing improvements in handling of workpieces have been made. The ultimate is reached in this field in the present-day traverse-through machine where handling reaches a minimum—perhaps the greatest advancement of recent years.

Starting in a modest way with machines such as the Kingsbury, Langelier, or Snyder "unit type" for relatively small parts, *Fig.* 2, these "automatics" reach the present-day ultimate with such as the Ingersoll, Greenlee or Foote-Burt machines of amazing intricacy. The trend toward the extremely specialized machine which is outmoded instantly a design change is made on the workpiece, however, has been arrested with the introduction of the Baush station type machine. Here each unit is entirely separate from every other unit comprising the entity, completion of the cycle of each unit initiating the cycle of the next unit. Thus where design changes arise only that portion of the machine affected need be removed and tooling revamped.

Flexibility of setup and operation has been brought to a high degree of attainment with most of the new machines. Although continuous improvement in machine tools, so evident in these latest models, helps eliminate many of the former limitations, in all probability complete freedom from design limitations can never be completely realized. The keynote, therefore, must be—and rightly so—to design with the processing limitations in view. In all probability no other approach offers greater opportunity for the achievement of maximum production at minimum cost.

Much in evidence among the production machines is an increased number of automatic grinders. Automatic surface grinders by Hanchett and Blanchard offer greatly increased output in the production of flat surfaces. This, however, is possible primarily where parts are designed to take advantage of grinding by limiting the amount of metal to be removed to about 1/16-inch or preferably less. However, 1/16-inch to 3/16-inch of stock can be removed with the cylindrical-wheel automatic rotary table machines to close accuracy through use of multiple heads. One roughs, one semifinishes and the final head finishes. Heavy stock removal can be had with accuracies to

Fig. 5—Below—New Britain automatic turret lathe is primarily intended to bridge the gap between the automatic screw machine and standard turret lathe



possibly plus or minus 0.002 or 0.003-inch. Where stock removal can be light—say 1/32-inch or less—accuracy can be brought down to as close as plus or minus 0.0002-inch. Automatic wheel feed and workpiece gaging eliminate handling and inspection. One limitation, though, is that parts must be unobstructed by projections to allow free sweep of the wheel.

Range of materials which can be ground has been extended to cover practically all of the available engineering materials, and limits of accuracy which can be maintained approach closely the flatness of optical flats, surface finishes being within several microinches. A precision way grinder by Giddings & Lewis, *Fig.* 3, develops surfaces having a flatness varying only a few tenths of an inch over a length of twenty or more feet. Grinding may be done at any angle required for all varieties of machine ways.

Design possibilities in grinding other than flat surfaces are extended considerably by machines such as the Geargrind universal oscillating grinder. This machine makes possible production grinding of internal or external spherical, conical and cylindrical surfaces on small parts. The picture is broadened to a still greater extent by grinders such as Bryant and Cincinnati chucking grinders, Cincinnati and Landis Tool centerless grinders, and a wide variety of plain grinders all of which feature automatic controls and superior accuracy. Cincinnati's new 10-inch plain grinder features an innovation which forecasts a new high in grinding quality. Automatic wheel balancing after every dressing eliminates the age-old grinding bugaboo—wheel unbalance surface markings.

Special machines such as the Landis centerless thread grinder and crankshaft grinder are little short of amazing. On the crankshaft grinder the grinding cycle is entirely automatic, wheel dressing is semiautomatic hydraulic and loading is accomplished with a semiautomatic counterbalanced loading fixture. Three main bearings, gear fit, fan fit, and O.D. of flange are finished in one operation on cranks up to 40 inches in length.

Also in the forefront of the production design picture is the turning operation, too often overlooked. The well known lines of screw machines have been implemented considerably. Brown & Sharpe's line now includes extremely small high-speed screw machines for parts up to ⅜-inch diameter and ¾-inch in length. A special automatic pinion-turning machine, *Fig.* 4, is unique in its unusual arrangement for producing delicate staff and pinion type work up to ¼-inch in diameter and 2⅞ inches in length by single-point action and a turret type operation.

Outstanding among the wide variety of screw machines are the Warner & Swasey and Cleveland automatics. These machines feature universal camming, providing cams which are easily accessible and adjusable primarily for short-run work. These machines make available the well known screw machine speed and economy over a much broader field of design.

Bridging the gap between the automatics and the turret lathes which were much in evidence is a new line of New Britain automatic turret lathes. Developed for full use of carbide tooling and quick changeover, these units have two heavy forming slides, two

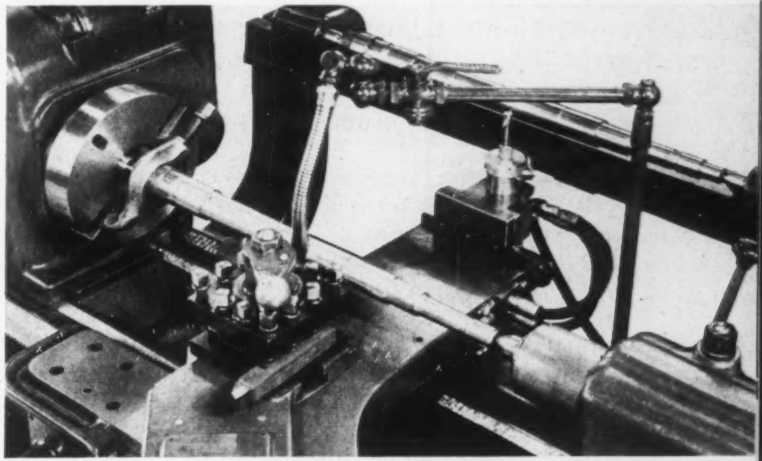
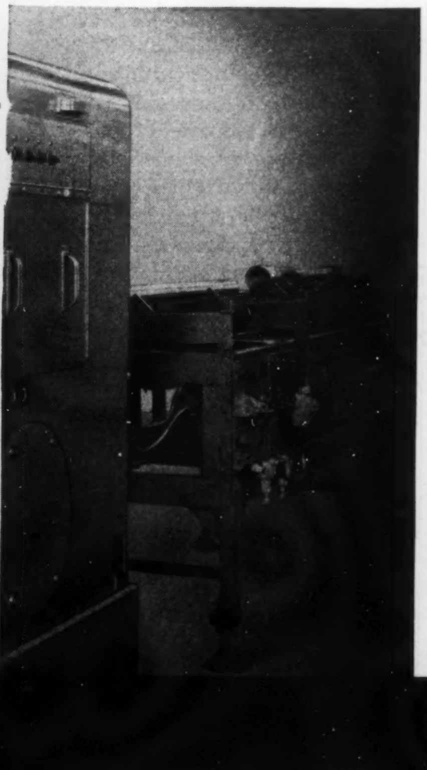
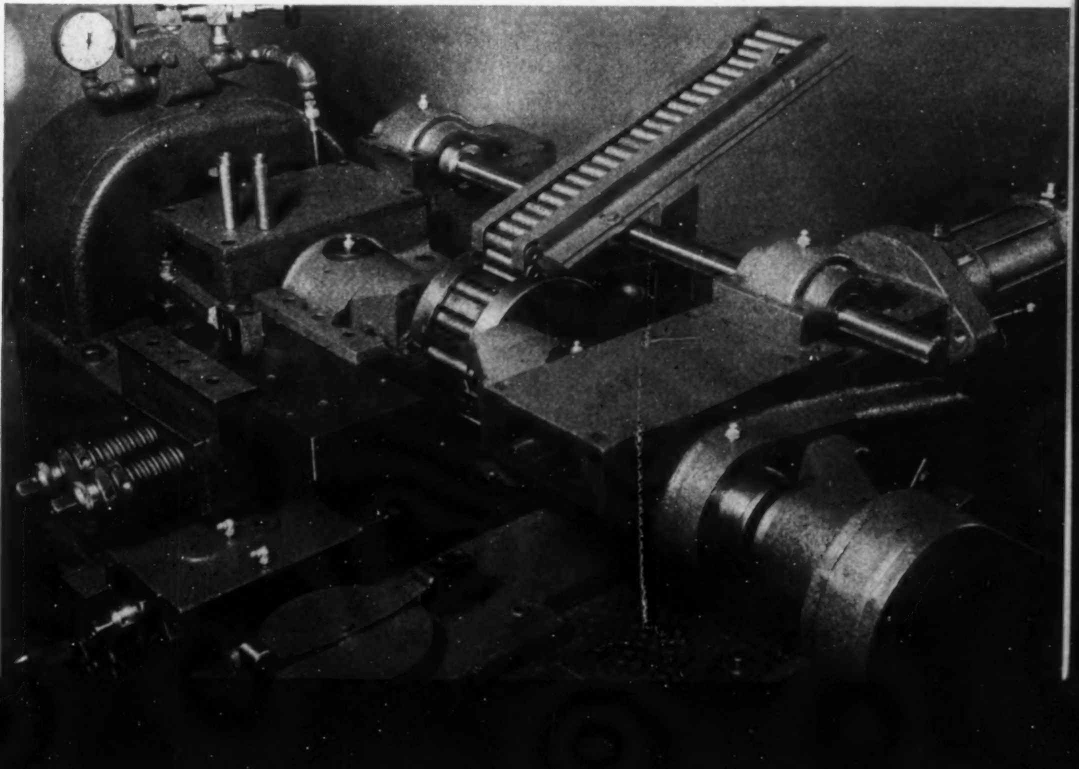


Fig. 6—Above—American hydraulic duplicator lathe reproduces a variety of shaft designs using a shaft pattern

Fig. 7—Below—Lo-Swing IMP automatic lathe loads valve guides, rough and finish turns, unloads, without attention





cutoff slides and a main horizontal turret with 4, 5 or 6 faces, *Fig.* 5. Setups are quickly and economically made for 10 or 10,000 pieces and models for 3, 5 and 8-inch diameter parts are available.

Completing the turning operations are a wide variety of new automatic cycle and automatic tracer lathes with automatic loading. Outstanding among these is Monarch's Magna-matic, which features simple set-up and make possible automatic production of both simple and complicated turned parts in large or small lots. Any number of diameters and lengths with intervening tapers or contours can be produced with the front carriage while facing, boring, necking, forming and chamfering operations are ordinarily produced with the rear carriage. American Tool Works hydraulic duplicator, *Fig.* 6, produces a wide variety of shaft designs using a part as a pattern.

Broadening the design possibilities of automatic lathe production are the Monarch air tracer machines. These accurate turning machines, supplementing the well known Shapemaster, bring to the field of turned parts an economy, accuracy, duplication, and speed on a par with that of the automatics. Design intricacies heretofore impossible to produce are now at the designer's fingertips at no premium in cost or production handicap relative to interchangeability.

Lathes Incorporate Automatic Loading

Perhaps most spectacular among the automatic-cycle, automatic-loading lathes are the Fay automatics featured by Jones & Lamson and the Lo-Swing IMP lathes featured by Seneca Falls Machine Co., *Fig.* 7. Not exactly new to the trade, the up-to-date versions of the Fay automatics, however, are uncanny in their rapid loading of blank parts, turning and unloading of finished parts without attention. Special fingers are employed to grasp the particular part being produced, pick it from the stock feed chute, place it in centering or chucking position, remove it and place it in the unloading chute.

Not to be overlooked in the turning field are the Cleveland Rigidturners. Employing a novel principle for tooling, these vertical lathes for both high and low-production runs utilize a horizontally mounted single generated cutter which rotates in controlled timed relation with the vertically centered stock as it advances past the cutter. Practically any shaft design can be produced on these machines which are available in two-spindle or eight-spindle models.

In the field of milling perhaps one of the most interesting new machines is the Cincinnati 000-4 unit type midget. Available in a model incorporating four machines on a single base this machine brings the assets of automatic milling into a size range heretofore not available to the designer. Featuring a maximum table travel of four inches, these units are especially adapted to the precision mass production of small components such as those used in cash registers, calculating machines, computers, etc.

Highlighting the somewhat new field of milling not too often thought of in production design—turn milling—is another extremely interesting machine designed expressly for turn milling crankshafts, *Fig.* 1. While completely special this machine shows vividly what can be done in this field, especially where rapidly work-hardening materials are employed. Produced by Gisholt, this unit turn mills the pins and cheeks of six-throw crankshafts using six 24-inch diameter, carbide-tipped cutters operating at a cutting speed of 470 feet per minute. Productionwise it turns out a crankshaft complete in 1½ minutes.

In the press field several new machines are outstanding. The Lempco Hypermatic press features unusual speed and design. This press operates at speeds up to 1800 strokes per minute with stock feeds up to 5600 lineal inches per minute on the 10-ton model or up to 10,000 inches per minute on the 50-ton model. Stock feed is constant, crank-actuated motion of the dies virtually blanking during traverse.

Another automatic press featuring extreme accuracy and admirably adapted to use of carbide dies is the new Henry & Wright design, *Fig.* 8. Well adapted for progressive die work these machines are equally satisfactory for high-speed blanking or high-speed blanking and intricate forming or drawing operations. Speeds available range up to 1200 strokes per minute. Available in a wide range of capacities, these high-production machines open a tremendous field for designers interested in taking advantage of the many economies and design possibilities afforded with precision stamped or drawn components.

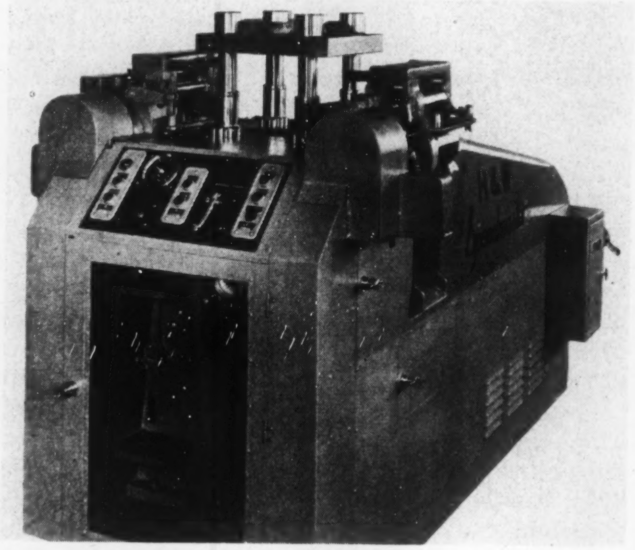


Fig. 8—Henry & Wright Speedmaster press especially adapted for carbide die and progressive stamping operations including forming and drawing

Broadening the field of design and production in thread and form rolling, a new thread roller by Landis Machine is of great interest. Primarily for rolling of studs having a fine thread on one end and a coarse one on the other end, this thread roller will produce any combination of threads, knurls, markings, etc., on diameters up to ½-inch and individual thread for form lengths up to ⅝-inch. Completely automatic with hopper or magazine feed, this thread roller will produce consistent accuracies up to those characteristic of class 5 threads.

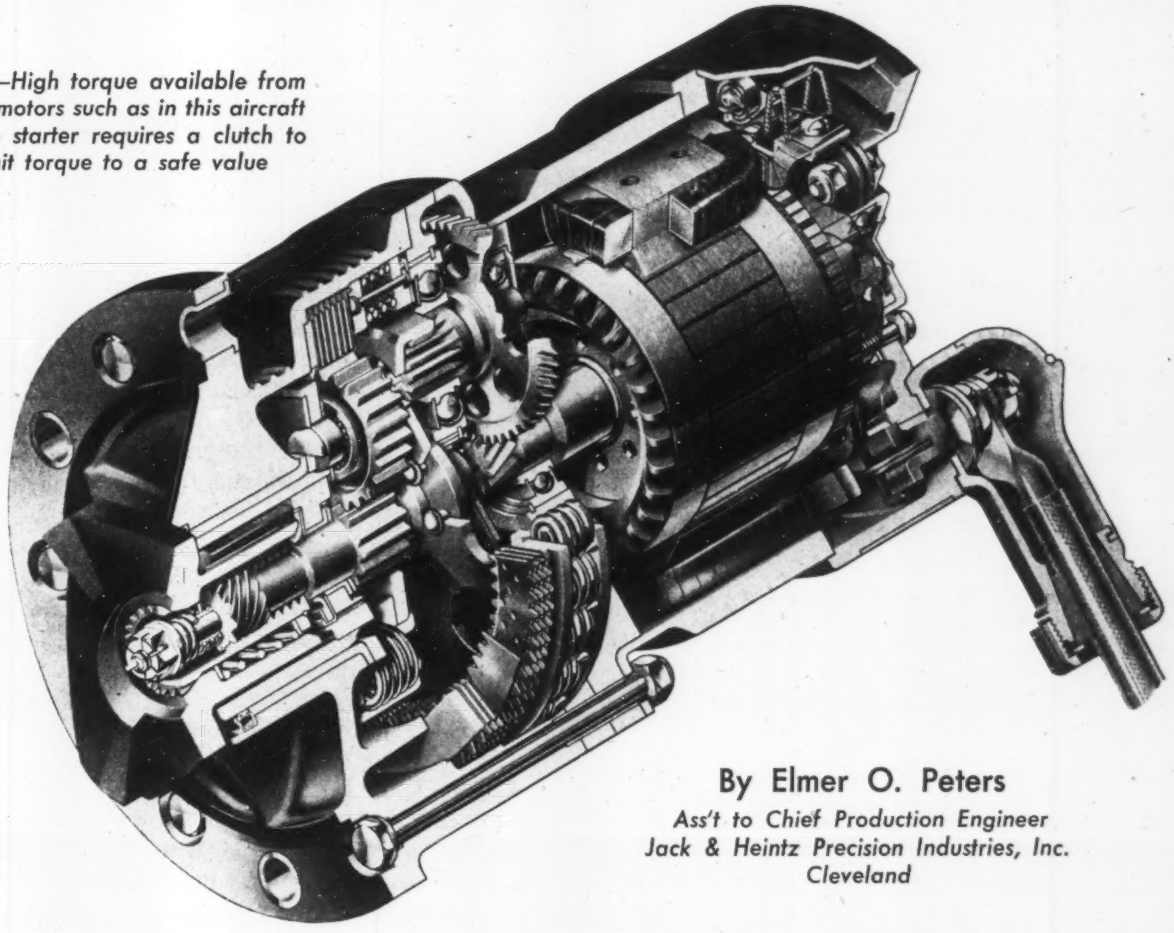


Fig. 1—High torque available from series motors such as in this aircraft engine starter requires a clutch to limit torque to a safe value

By Elmer O. Peters
Ass't to Chief Production Engineer
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Cleveland

Controlled Friction

... between disk-clutch elements precisely limits torque and eliminates undesirable vibration

SERIES type electric motors used in aircraft engine starters are such that upon actuation there is sufficient time for the motor to reach considerable speed before the jaws engage. Because of the extremely high starting torques available from these motors, the sudden engagement of the moving starter jaw with the stationary engine jaw would develop forces sufficiently high to damage the engine or starter severely. To prevent such damage, use of a friction clutch proved to be the simplest means for limiting transmitted torque to a safe value, *Fig.* 1.

Function of the clutch, of course, is the same in case of an engine backfire which drives the engine and starter backwards as in starting; slippage occurring when the load exceeds the predetermined set value. The problem, however, was not so simple owing to inconsistent clutch characteristics inherent in prevailing designs which ultimately led to trouble and failures. It is with this problem of clutch design that this article will be concerned and it is hoped that it will assist in the solution of other similar machine drive problems.

In normal direct cranking action, the internal gear clutch plates are held stationary by the friction of the bronze clutch plates with which they are interleaved, *Fig.* 2. When the cranking torque, imposed by the engine, exceeds the clutch setting, the internal gear clutch plates slip and dissipate the energy, allowing the planet gears to rotate while the planetary carrying arm and the jaw remain stationary. When the engine comes up to the speed at which the starter is trying to drive it, the torque drops off to a value less than the clutch setting, the internal gear clutch plates are again held stationary, and the jaw rotates at the speed of the motor. Thus, as used in aircraft engine starters and actuators, the multiple-disk clutch is designed primarily to limit output torque so that physical damage will not occur to any component of the starter, engine, actuator, or mechanism being actuated.

In the form originally incorporated in units of this type, multiple-disk clutches chattered, were rough in operation and set up undesirable transient torque characteristics under conditions of slip. Instead of providing a smoth, slipping torque, torque transmission was spasmodic with an inconsistent torque limit. As a result, serious stresses were placed not only upon the gear train and other parts of the unit itself, but also upon the components of the engine or mechanisms to which the torque was transmitted. It was therefore necessary for Jack & Heintz engineers to redesign the clutch to eliminate these highly objectionable features.

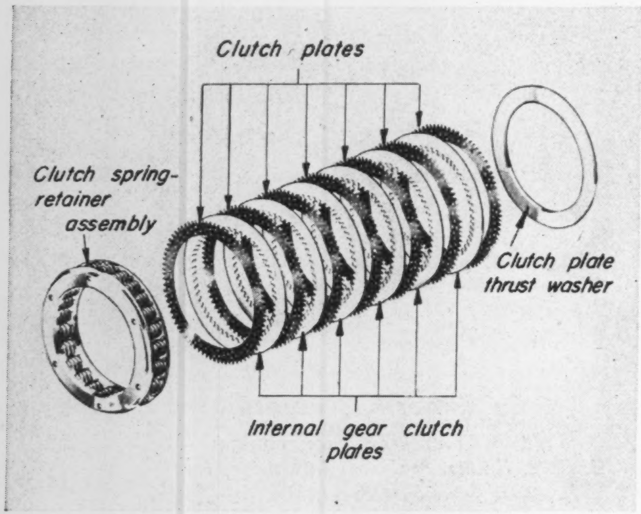

Clutch plates
Clutch spring-retainer assembly
Clutch plate thrust washer
Internal gear clutch plates

Fig. 2—Exploded view of disk clutch elements employed in the aircraft engine starter shown in Fig. 1

For simplicity and ease of comparison, the data in this article will concern only one project; the design and development of a starter for an aircraft engine of 2600 cubic inch displacement, with a 1 to 1 ratio between starter jaw and engine crankshaft. The torque limit (clutch slipping) for this starter is 750 foot-pounds minimum and 950 foot-pounds maximum. The starter is for electric direct cranking only and has no handcrank equipment for external energizing, no flywheel, no brush lifting mechanism, and no independent control of the engaging jaw. When the motor is energized the starter jaw is mechanically engaged to the engine jaw; when the engine starts the sloping ramps of the teeth disengage the jaws and the starter motor, de-energized, comes to rest.

GENERAL DESIGN DATA: Specific data which can be assumed to be fixed by the original design and those necessarily inherent in the materials employed are: (a) Inside diameter of internal gear plate is 3.750 inches; (b) coefficient of friction f of clutch-plate material and lubricant equals 0.1; (c) with the limitations on the height and diameter of the springs to be used as set up by the limited outside diameter of the starter, 24 springs can be employed; (d) to keep axial loading to a figure that will not put a load on the springs greater than that which can be held with the aid of helper springs 12 pairs of friction surfaces must be used; and (e) the torque T which is to be transmitted is 9000 inch-pounds at the pitch diameter of the internal gear plate. To find the axial load, T is divided by the quantity $f \times$ pairs of friction surfaces $\times$ mean frictional radius, or, $9000 \div (0.1 \times 12 \times 2.17) = 3456$ pounds. From this axial load the load per spring can be found; $3456 \div 24 = 144$ pounds per spring.

Experience has shown that 96 pounds load per spring is the maximum load commensurate with dimensional design limitations imposed by the starter design adopted. Therefore, with a load of 144 pounds it would be imperative that helper springs be employed. Both the main and the helper spring were designed along standard methods.

Early clutches utilized steel plates of various ground finishes against tin-plated phosphor-bronze plates perforated for lubricant reservoirs. These clutches were so decidedly rough in operation that several jaws were broken almost immediately after life tests were begun.

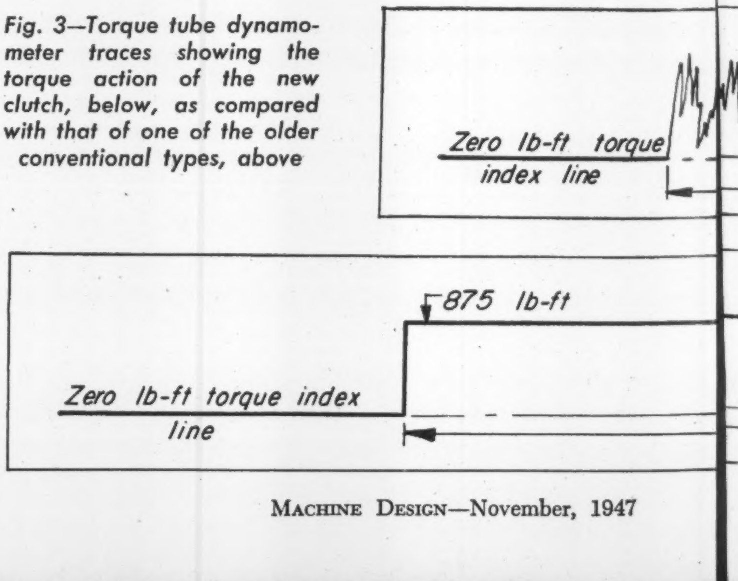
Generally speaking, the surface of the steel plates running against tin-plated phosphor bronze has little effect on clutch operation or durability. The tinned surface is effective on phosphor-bronze for only about 20 starts against a locked jaw. The tinning, and eventually the bronze, transfers to the steel, giving a bronze-on-bronze wearing surface which causes grabbing and chattering.

Torque tube dynamometer traces, *Fig.* 3, show the torque action of a smooth operating multiple-disk clutch as compared with that of a rough operating multiple-disk clutch. The oscillations as indicated on the traces represent a torque variation of 50 pounds per 1/32-inch in the ordinate.

Comprehensive tests were made with hard chrome-plated steel plates of various finishes, operating against tinned bronzes and plain bronzes. Chrome plating made the clutch operation smooth, but raised costs, not only because plating was required but also because of the necessity of tapering the clutch pressure ring to compensate for the 0.0005 to 0.0015-inch chrome build-up on the edges of the plates.

Chrome-plated steel plates proved rougher in operation when run against tinned bronzes than when

Fig. 3—Torque tube dynamometer traces showing the torque action of the new clutch, below, as compared with that of one of the older conventional types, above



run against plain phosphor bronzes. Torque settings appeared to hold equally as well against phosphor bronzes as against tin-plated phosphor bronzes.

While being life tested, clutches with chrome-plated and phosphor-bronze plates gradually dropped about 150 foot-pounds in torque setting during the first 1200 starts, thereafter carrying back to original value.

Severity of the locked-jaw test of a starter in comparison with actual use on aircraft should be recognized. In this test a jaw similar to the type used on an aircraft engine is mounted stationary on a test block and the starter operated against it. A test cycle is the period of time (three seconds) that the starter is caused to slip. Life tests show that after 2000 cycles the clutch limits ordinarily change radically. The average period of time a clutch slips, when starting an aircraft engine, is 0.4-second. Two thousand test cycles against a locked (stationary) jaw provide, therefore, the equivalent of approximately 15,000 satisfactory engine starts.

Inspection of earlier clutch designs showed that the oil holes became clogged and that material tended to pile up at the spots where the oil holes were located. These high spots caused the bronzes to burn and the steel to wear in narrow concentric rings.

Recent clutch tests prove that the necessity for plating steel clutch plates can be eliminated by compounding lubricants, by increasing the number of oil reservoir holes to enable a greater surface lubrication, and by specialized grinding of the steel plates. A fine pulverulent hard material, added to a grease base, acts as a polishing agent and, at the same time, greatly stabilizes the slipping characteristics of the clutch plates, eliminating the transfer of bronze.

Perforations in the plates retain the lubricating mixture in intimate contact with the sliding surfaces, thus exerting a polishing action with each slippage of the plates. Surface polishing consists of making a multitude of extremely fine scratches which remove high points and irregularities of greater relief than the scratches themselves; these scratches form microscopic lubricant-retaining grooves which make available to all sliding parts an ever-ready supply of lubricant which cannot be squeezed out by static force or rubbed off by wiping action. The lubricant is thus distributed uniformly over the whole surface before slippage starts and tends to equalize breakaway and sliding frictions. The extremely close spacing of the minute lubricant channels eliminates any possibility that localized dry spots may produce hot spots capable of transferring particles of bronze to the steel plates, causing grabbing and chattering.

The clutch torque limit is caused by the friction set up between the clutch plates which is adjusted by the compression applied on the clutch springs. The coefficient of friction of the plate materials and lubricant was determined, by trial and error, to be 0.1.

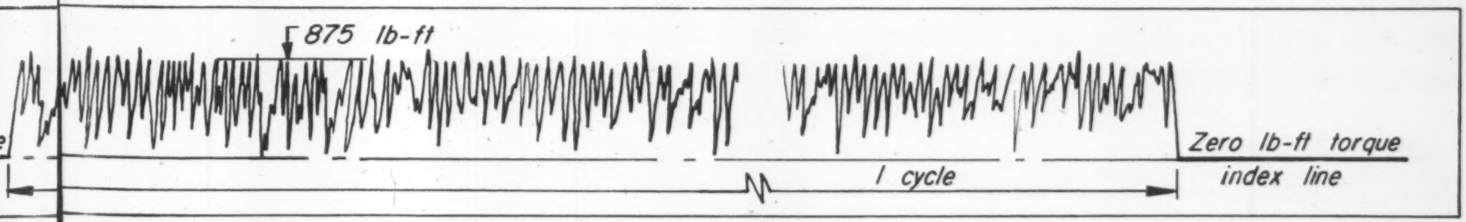
TABLE I

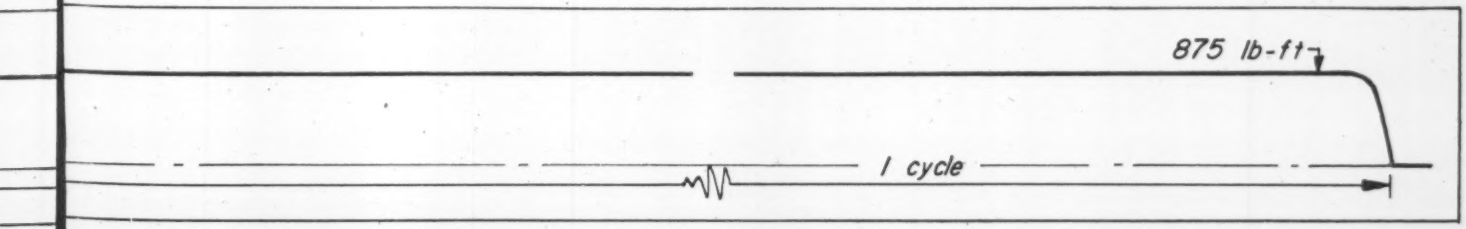
Spring Materials and Characteristics

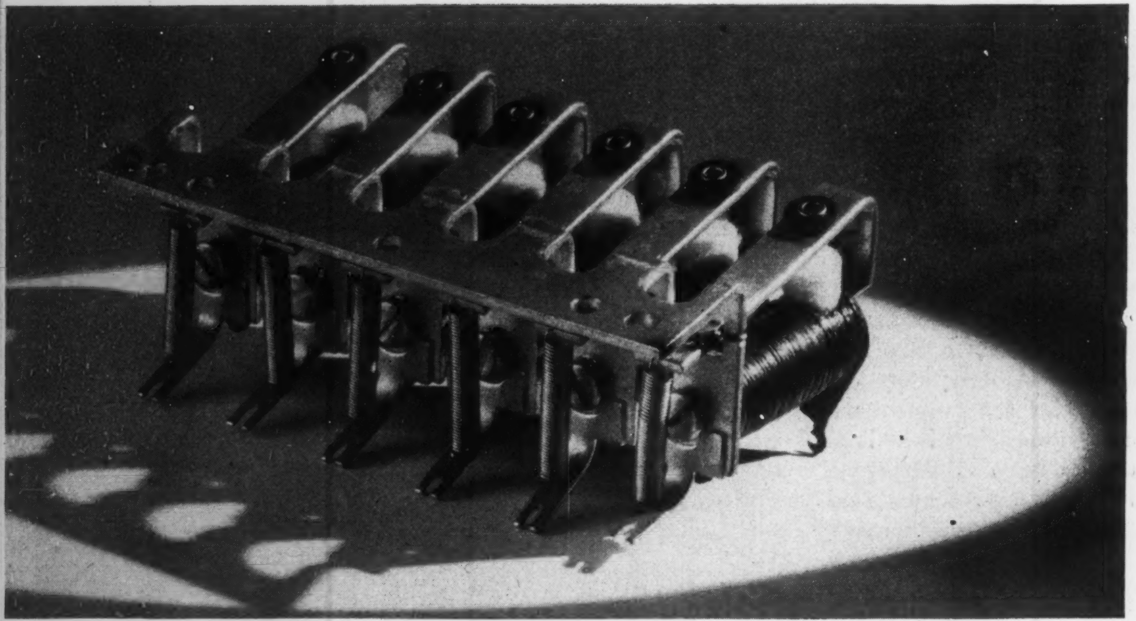
Material	Load Before Run (lb)	Load After Run (lb)	Set (per cent)
Spring Design A Carbon Steel	60	52	15
Chrome Silicon	60	56	7
Spring Design B Carbon Steel	38	31	22
Chrome Silicon	38	34	12
Spring Design C Chrome Vanadium	79	76	4

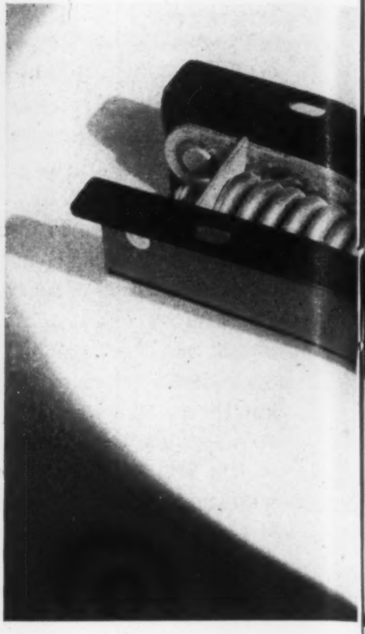
Material for the springs used in early designs of the multiple-disk clutch was a carbon steel. This steel was severely overstressed and was therefore changed to chrome-vanadium wire. Data which led to this decision are outlined in TABLE I. Since there was but a limited space for the springs, it was necessary to use square wire and small helper springs mentioned previously to get the required load capacities.

The torque at which the multiple-disk clutch slips can be reduced by removing small helper springs and increased by adding shims. Removal of the springs decreases the pressure applied on the clutch plate stack; the addition of shims increases that pressure. This type of disk clutch operates equally well in either direction of rotation, and has proved superior in reliability and performance to every means which had been used prior to its introduction.









Specifying for Economy in Springs

By Ronald F. Pond

Spring Engineer
Reliable Spring & Wire Forms Co.
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Part I

EVERY time an engineer draws up specifications for a new spring he has an interesting opportunity. Depending entirely on how he states his requirements, he can cause his company to pay, say, $3.50 or as much as $15.00 per thousand for a spring to do an identical job.

In order to specify a spring in the lowest possible price class, the design engineer must deal with information beyond that concerning load and deflection formulas, corrected fiber stress, and stress concentrations. He needs an understanding of some of the facts of practical spring manufacturing. Also, anticipation of variations resulting from assembly practices, *Fig.* 1, is an important economic factor in spring design.

Any engineer, developing or revising his spring designs for economy, should realize first of all that it is through the manner in which he states his specifications that he can most easily approach his goal. Available to him, as a basic method, is the simple device of so stating his requirements that the spring manufacturer may thoroughly understand the problem, and be unhampered by specifications that are not truly mandatory.

While the basic method can be stated briefly, putting it into effect is another matter. To complicate the situation there is, for instance, the factor of quality control, which accents a truth everyone knows, but which never can be over-emphasized: *No spring is cheap which fails to do its job.*

This leads direct to another facet of the situation: A spring often is the cheapest part of an assembly. But there is no point in simplifying the spring to the point where the cost of adjacent parts, or the assembly operation, is increased out of proportion. It is much wiser for an engineer to authorize changes which double or treble the cost of the springs, but in so doing clip minutes from assembly time—minutes which cost far more than the increase in the unit price of the spring.

In other words, specification policies should be aimed at the target of overall economy, rather than at simply trying to arrange for the purchase of consistently cheap springs.

Turning from generalities to the particulars of design and specifications, the engineer has to deal with the four basic elements of all spring problems: Space, load, deflection, and working conditions.

In the majority of applications, the first element, space, is the most important. Due to the natural trend toward lighter weight and more compactness in design, springs are being required to function in a re-

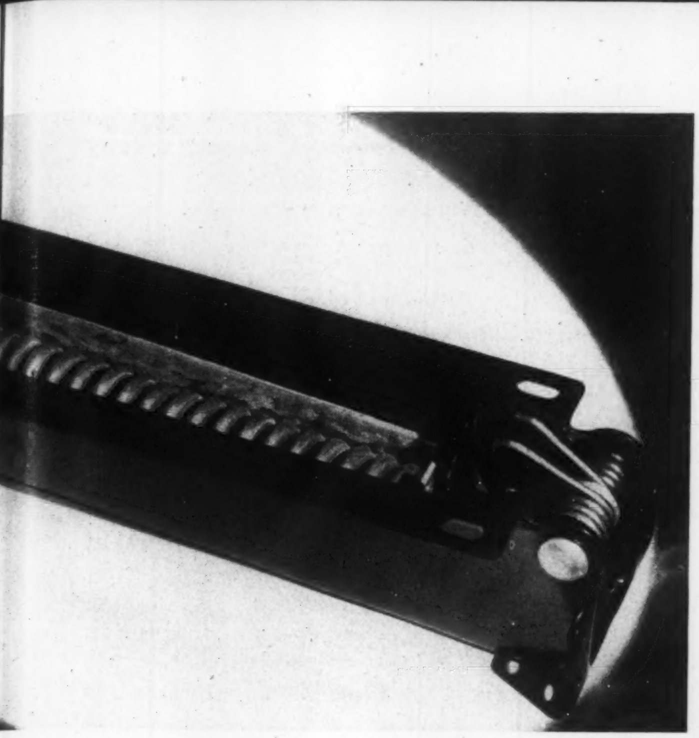
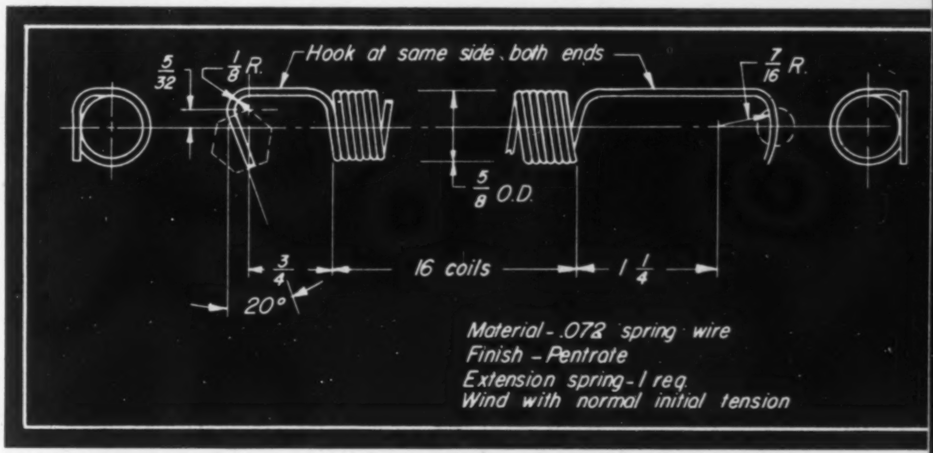


Fig. 1—Far left—By providing mild steel angular attachments arms which are readily adjustable, the designer has facilitated making adjustments to compensate for slight distortions in spring ends which are apt to occur during assembly of these delicate extension springs

Fig. 2—Left—Compression spring for counterbalancing lid on freezer unit. Rate of spring and avoidance of solid height are design factors. Adjustment for counterbalancing position simplifies spring manufacturing and allows for variations in assembly. Adequate space has been provided to facilitate spring design. The torsion springs have 1/16-inch added to the ends beyond the bend, saving several dollars for each thousand by obviating trimming

Fig. 3—Below—All necessary information should be included on drawing. Mating parts such as those shown for spring ends should be indicated by dotted lines


5/32
1/8 R.
Hook at same side, both ends
7/16 R.
5/8 O.D.
3/4
16 coils
1 1/4
20°
Material - .072 spring wire
Finish - Pentrate
Extension spring - 1 req.
Wind with normal initial tension

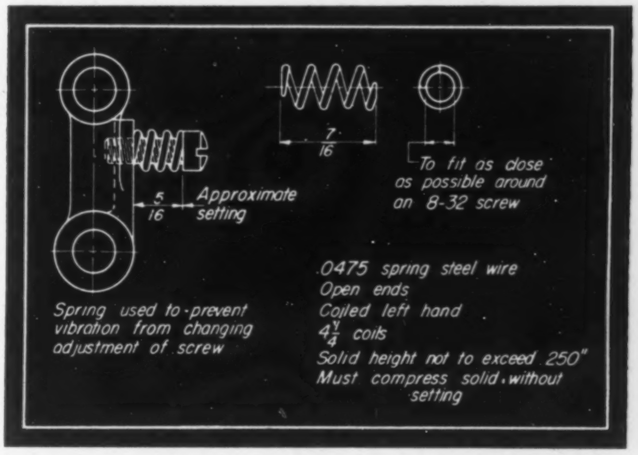

7/16
To fit as close as possible around an 8-32 screw
5/16
Approximate setting
.0475 spring steel wire
Open ends
Coiled left hand
4¼ coils
Solid height not to exceed .250"
Must compress solid without setting
Spring used to prevent vibration from changing adjustment of screw

Fig. 4—Drawing, showing spring application and specific design information, is a desirable way of specifying

stricted space, *Fig.* 2. In general, the engineer's best course, whether or not he considers space very restricted, is to furnish all pertinent space information, in addition to the dimensions he has worked out in the process of designing the spring.

By furnishing full details concerning space the engineer accomplishes two things: He makes it possible for the spring company to suggest changes which will bring the cost down, and he places on the spring manufacturer inescapable responsibility for proper fit.

The practice of including hole and rod diameters in compression spring specifications is becoming more and more common. There is no valid reason why it should not be universal. Instances where space information is given covering the applications of other types of springs are rare in spite of the fact that more important cost savings can result in extension and torsion spring applications than is generally possible in the case of compression springs. Price reductions could come through simplification of spring end designs as well as through changes in material grade and size, with the further possibility of overall cost savings through changes which reduce assembly time.

As to the best methods of giving space information to a spring company, in the many instances where this cannot be accomplished merely through the adding of a few words and figures to the drawing or specification sheet, two methods exist which are convenient and sure fire.

The first, which is time honored and almost a custom with some firms, is to send or bring the mechanism itself, or a subassembly, to the spring manufacturer. Any time and trouble involved in this procedure will pay dividends. The other practical method is seldom used. It consists simply of including the mating parts or surfaces on the detail spring drawing. As suggested in *Fig.* 3, these adjacent parts can be traced on the original transparency from other drawings, and should be shown in dotted lines. Few dimensions would be needed in most cases. *Fig.* 4 shows another method, which is advisable in instances where many dimensions must be given in connection with the view of the spring.

The importance of including space information in specifications can hardly be overstressed. Its use will mean that—assuming other pertinent information covering activity, working temperature, and corrosive conditions is mentioned—the entire story of the spring application will be shown.

Combining Load and Deflection Data

While malpractices occur in all phases of spring specifications, those which occur in connection with load and deflection are the most dangerous. Often, specifications reach the spring manufacturers in which the load requirement is not tied to a specific deflected position. In many instances this error occurs where information as to wire size is left to the discretion of the manufacturer. The reverse: Deflection information minus a load requirement is equally common, and leaves the spring manufacturer at a loss as to what the customer really wants. Also there are cases where no load requirement is stated, but it is found to be implicit in the close tolerances applied to all dimensions. In other words, if a close load tolerance is required, it should be applied to the loads, and not to the dimensions.

In all instances, tolerances should be considered as carefully as any other element of the design problem. If dimensional, they will deal primarily with the matter of fit, but also with functional quality, since variation in dimensions necessarily affects the spring rate. On the other hand, both dimensional and load tolerances have an intimate relationship to costs, since they affect manufacturing speeds. When very close they require expensive supplementary operations such as gaging, load-testing, and grinding operations.

There is no question but that load tolerances are set arbitrarily on too many springs, according to whether or not the spring is considered "critical." In the case of springs which have a vital function to perform, time will be well spent in determining the actual load range which will insure the action the mechanism must have. If conditions in a particular case make the computation of a practical load range impossible, it may be convenient to get the answer by experimenting with weight tests. In other instances the only course is to secure a small quantity of sample springs which will provide a range of loads. By selecting from the lot as many springs as possible which have the proper characteristics, the actual working tolerance can be determined.

Two things more should be said about tolerances and their effect on price: One is that load tolerances of plus or minus 10 per cent on compression and extension springs, and of plus or minus 20 per cent on torsion springs, are sufficiently large to permit near maximum manufacturing speeds. Secondly, there is the perhaps obvious observation that the cheapest prices of all fall on those springs for which no load requirements and no close tolerances are necessary.

The remaining basic element in spring design problems is the working conditions of the spring. Often it can be covered by a short, simple statement on the drawing. This subject, however, is an important one, since it covers such facts as exposure to corrosive fumes or liquids, temperature ranges, and activity rate. Many times, all that is needed is a concise statement of the overall use of the spring.

By informing the spring manufacturer of the spring's working climate, the designer makes possible a verification of the selection of both materials and finishes, which sometimes leads to recommendations of real value. Having the facts concerning extreme temperature ranges, for instance, the spring company engineers are in a position to consider the effects of temperature when checking stresses on a spring, as well as the material specified. These same factors should be considered in relation to activity.

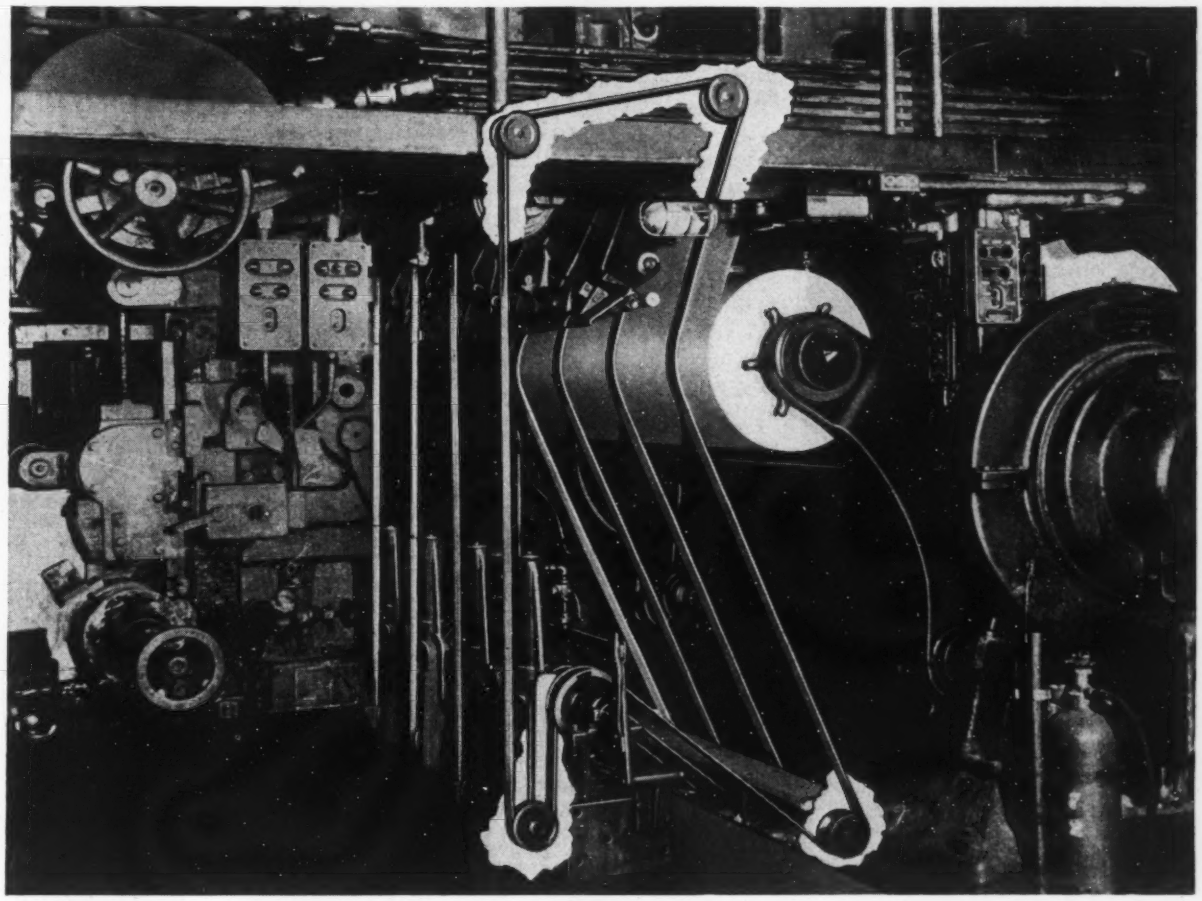
Materials and finishes will not be dealt with at length. These elements of the problem, judging by specifications currently being produced, give designers relatively little trouble. A few points, however, are worthy of mention. One, suggested particularly by experience in the production of "war springs", is that there is no reason for specifying an expensive kind of wire simply because a spring is important. Most springs are important, as a matter of fact, and if enough space is available, can be designed with sufficiently low stresses to give the spring all the endurance needed even though made from the cheapest grade of spring wire. High-priced materials, such as music wire, beryllium copper, and stainless steel, are correct only where space is limited, or where special electrical conductivity problems, extreme temperatures, or highly corrosive conditions are encountered.

Should Use Standard Gages

A second point regarding the specifying of materials, is that all design engineers should try to choose material sizes which conform to standard gages, and the data they furnish should include the size of wire in decimals, plus the gage name and number. The gage should be that regularly used by the mills in producing spring wire. Music wire, for instance, is best specified by the Music Wire gage, other carbon steel wires by the Washburn & Moen (steel wire gage), carbon steel strip by the Birmingham & Stubbs gage, and all copper-base alloys and aluminum by the Brown & Sharpe gage.

As for plating, it should be kept in mind that usually barrel-plating is the only economical method. Many springs and wire forms, however, have a remarkable and tenacious affinity for each other when tumbled. If a particular design is likely to tangle severely when the springs are in the plating barrel, attention should be directed to the possibility of specifying one of the precoated wires, though these coatings are poor substitutes for a regular plating job performed after the spring has been formed and heat treated. In some cases it may be found less expensive to use stainless steel or phosphor bronze, rather than to require cadmium or zinc plating.

All of the foregoing, as has been indicated, applies to specifications for all types of springs, and the ideas advanced have therefore been largely generalities. Part II, to be published next month, will be devoted to a discussion of design details.



Pneumatic Control Achieves Constant Roll Tension

By Charles S. Caffrey
Wood Newspaper Machinery Corp.
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IN PRINTING and allied industries, three-arm magazine roll stands are used in presses to support the unwinding roll as well as two full rolls ready for splicing-on with a minimum of delay. Numerous methods have been devised to provide the necessary tension on the unwinding roll. Weighted straps or belts which contact the surface of the roll have been popular primarily because they provide a simple method of applying braking to a roll where centers are movable, as they are where the magazine reel is rotated when loading or making a splice.

A perfect tensioning mechanism must perform two functions. It must hold a constant tension from the start to the finish of the roll and it must prevent the roll from running ahead if the machine is suddenly stopped. Multi-color gravure presses are extremely exacting in their requirement of a constant tension for the reason that if there is any slip or stretch in the paper between the various color units the colors

Fig. 1—Top—Cutaway view of printing press showing location of pneumatically actuated running-belt tension control

in the finished product will not be in register. Metropolitan daily papers normally feed four to eight rolls of paper at high speed into one press. If it should be necessary to stop the press for any reason, the tensioning apparatus must apply additional braking to all rolls or their inertia will carry them ahead, resulting in broken webs. As a roll wears down the arc of contact of the belt decreases, thus requiring automatic tightening of the straps.

The Wood automatic tension control, *Fig.* 1, provides all these necessary functions employing endless running belts which travel approximately two per cent below web speed. Four 2-inch belts are used for a 68-inch newspaper roll, each tightened by a pneumatic piston. The pistons have sufficient travel to keep the belts in contact with the roll regardless of position of the reel or whether the roll is full diameter or nearly consumed.

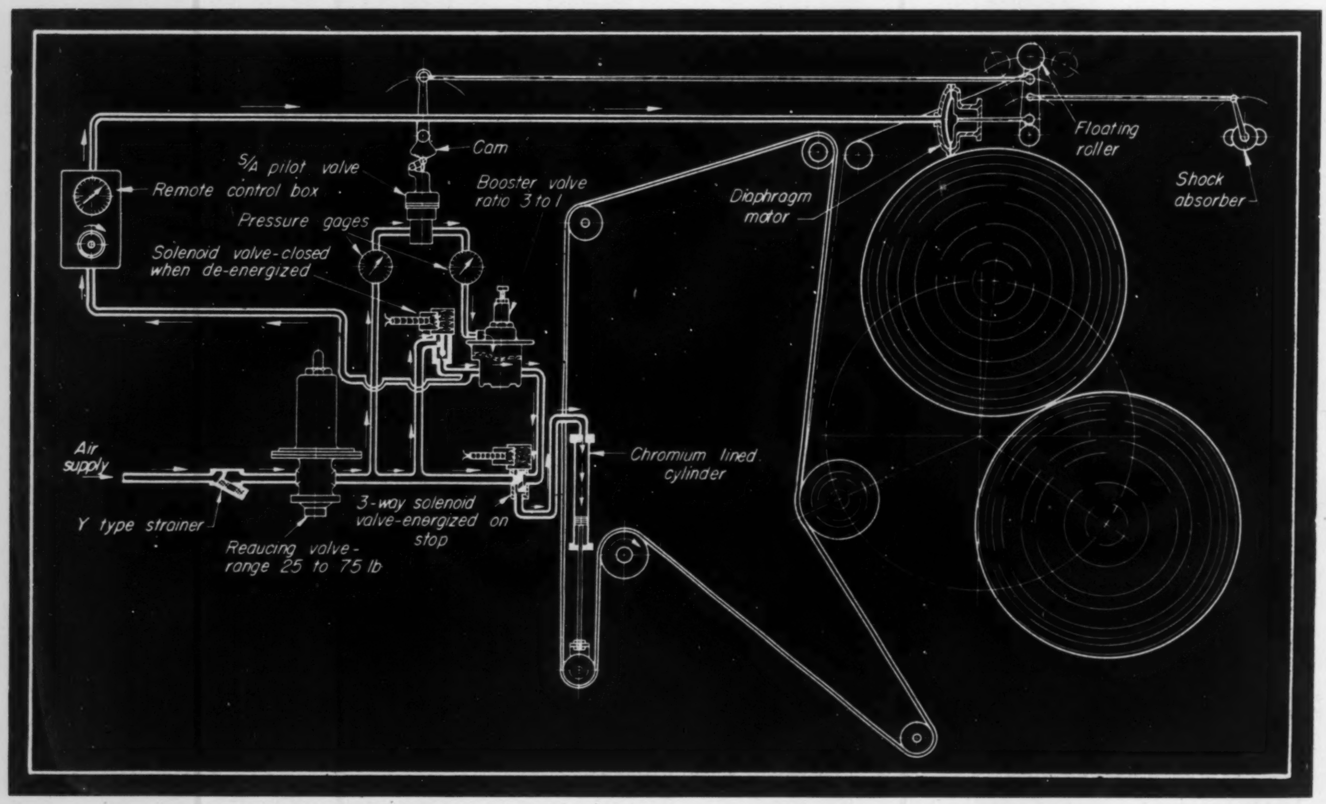
For quick stops, generally called red-button stops, air pressure of a fixed predetermined value is applied direct to the pistons from the instant the red button is pushed until the press comes to rest. To maintain constant tension for normal running the pressure is automatically controlled. As the schematic drawing of *Fig.* 2 shows, the web travels over a floating roller which is free to travel through an arc. An air piston or diaphragm motor exerts an adjustable pressure on this roller forcing it in one direction. The web is directed over this roller so that it tends to pull the roller in the opposite direction.

Connected through linkage to the floating roller is a cam which operates an air valve to control the air in the pistons, thus obtaining automatic regulation of running tension. Any value of web tension between the maximum and minimum requirements of the press are obtainable by manually adjusting the air pressure on the diaphragm motor. A remote control station is provided for this, containing the necessary regulating valve and also a pressure gage which is a direct indicator of the web tension.

To simplify the piping of these parts, the valve which is operated by the floating roller is a pilot valve requiring only ¼-inch copper tubing. This pilot valve in turn operates a booster valve, which is contained in a box along with the necessary magnetic valves and main reducing valve, the box being located close to the pistons.

Air supply is first brought to a main reducing valve, which will take a variable input pressure but will deliver a constant pressure—normally 50 pounds—to the apparatus. On red-button stops this pressure is applied direct to the pistons by a magnetic valve which also cuts off the air circuit controlled by the floating roller. For normal running where constant tension is required, the 50-pound pressure passes through another magnetic valve into the booster valve, where it is reduced in accordance with the regulation it gets from the pilot valve, and thence to the pistons. While the floating roller control will hold a web taut on normal deceleration, its response might not be quick enough on red-button stops to prevent some slackening of the web and it is for this reason that the separate red-button stop control is used which starts functioning at the instant the button is pushed. This second magnetic valve is energized only when the press is in motion and is closed when the press is at rest, thus conserving air and stretch in the belts.

Fig. 2—Diagram of running-belt tension control system



Wichita City Lib

Welded Flanges

. . . calculations and tests indicate no advantage of code-approved joint over simple butt weld

By G. A. Brewer
Consulting Engineer
Laguna Beach, Calif.

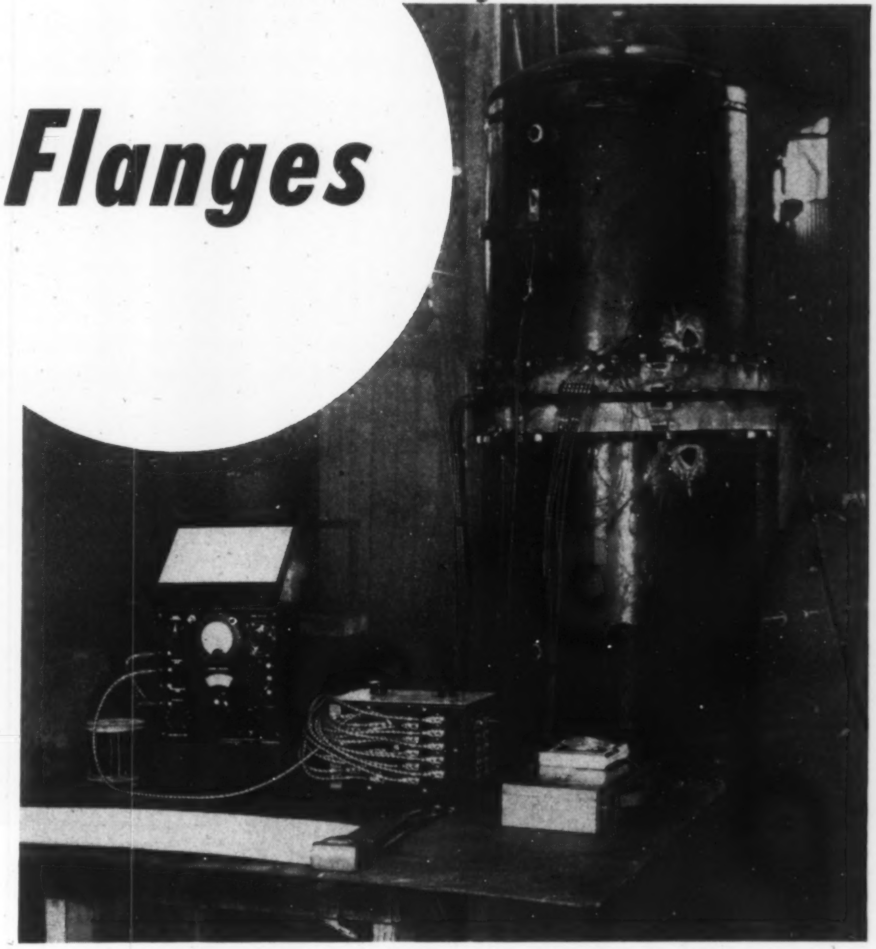


Fig. 1—Pressure vessel with strain gage measuring equipment

IN ORDER to compare the calculated and measured stresses in welded flanges, the small pressure bottle shown in *Fig.* 1, was tested, using strain gages affixed in critical locations. The tank is of the type used in the refining industry for the confinement of fluids and gases under moderate pressure and temperature. It is sealed by means of a steel jacketed asbestos ring clamped between the girth flanges. These are drawn together by through bolts as shown in *Fig.* 2.

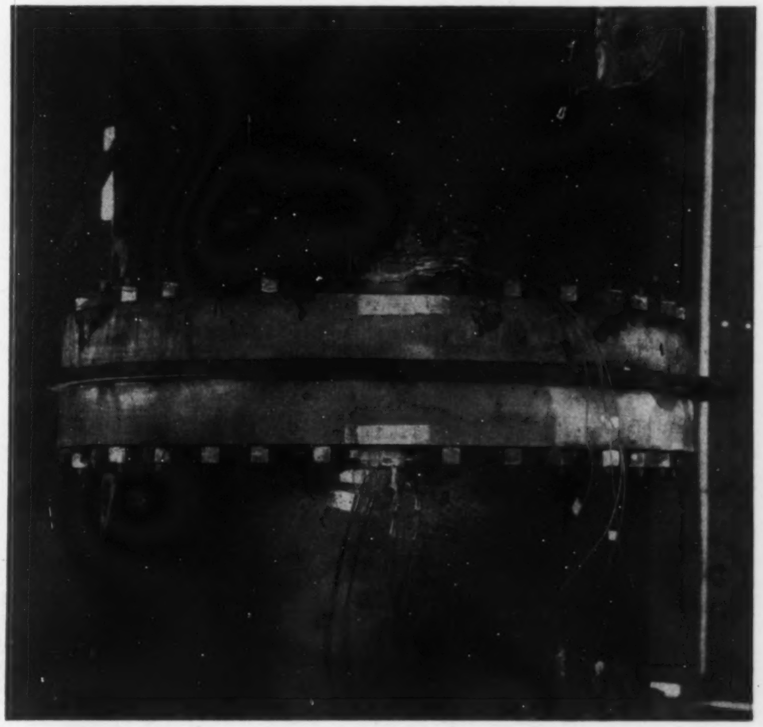
The tank is designed to work at an internal pressure of 267 psi and should withstand an overload pressure of 650 psi before failure. Referring to *Fig.* 3 the total force opening the flanges at 650 psi will be:

$$\frac{p\,D^2\,\pi}{4} = \frac{650\,(27)^2\,\pi}{4} = 373\,000 \text{ lb}$$

where p = internal pressure of tank (psi) and D = diameter of tank subjected to pressure (in.).

Two gaskets seal the tank on each side of the steel spacer. These gaskets comprise an asbestos ring 0.125-inch thick by $\frac{1}{2}$-inch wide covered with a mild steel jacket. The gaskets then are quite rigid and it may be assumed for design conditions that the tank will leak when the bursting load is equal to the clamping load;

Fig. 2—Flanges of vessel with strain gages cemented to weld fillets



thirty-six bolts, ¾-inch diameter NC 10 threads per inch, Class II fit are spaced around the center line of the girth flanges, tightening of which clamps the flanges down on the gaskets. The bolts are machined from 4140 steel having an ultimate tensile strength of 125,000 psi. For this study the threads and nuts of the bolts were lubricated with grease and graphite, the hexagonal nuts being inverted to minimize friction.

Bolt loads and stresses may be calculated knowing the sealing load required as follows:

$$Q=\frac{\text{bursting load}}{\text{no. of bolts}}=\frac{373{,}000}{36}=10{,}350\text{ lb}$$

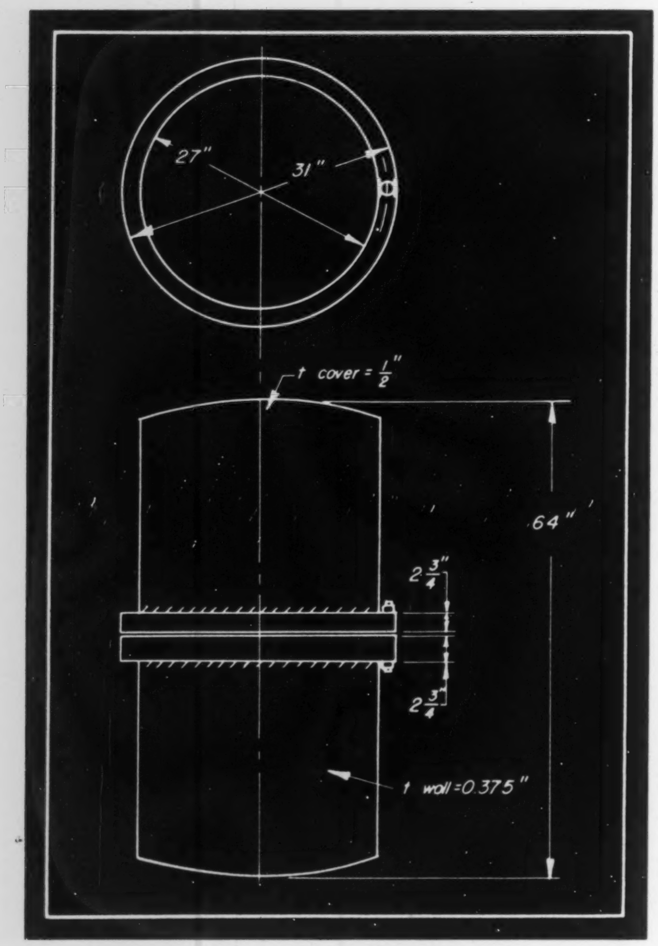


Fig. 3—Above—Sketch of vessel with dimensions

Fig. 4—Below—Flange bolt showing one of the two electric strain gages cemented to a filed face

$$f_t=\frac{Q}{\text{root area}}=\frac{10{,}350}{0.302}=34{,}300\text{ psi}$$

where Q = tension load per bolt (lb) and f_t = average tensile stress in bolt (psi).

The wrench torque required to tighten the ¾-inch bolts to a tensile load of 10,350 lb may be calculated using the formulas given in Reference* 1 is

$$T=Q\left(\frac{d\tan\alpha}{2\eta}+\mu R_m\right)$$

where

T = Wrench torque (lb-in)
d = Mean diameter of screw = 0.685-inch
R_m = Mean radius of nut face = 0.468-inch
μ = Coef. of friction = 0.111. (Reference 1 table 24)
$\tan\alpha$ = Pitch/(πd)
η = Efficiency = 0.264 (calculated)

Substituting, the wrench torque required to produce a bolt load, Q, equal to 10,350 lb becomes

$$T=10{,}350\left[\frac{0.685\ (0.0464)}{2(0.264)}+0.111(0.468)\right]$$

$$=1160\text{ lb-in or }96.5\text{ lb-ft}$$

Two electric strain gages were attached to the center of one of the flange bolts as shown in *Fig.* 4. At a wrench torque of 100 lb-ft the surface stress on the side of the bolt facing the vessel wall was 55,200 psi tension, while the outer surface of the bolt was found to be 16,050 psi, the average tensile stress in the bolt being 35,600 psi and the tensile load equal to 0.302 (35,600) = 10,750 lb, agreeing closely with the theoretically predicted load of 10,710 lb for 100 lb-ft using the formula for wrench-torque value.

The tank was then filled with water and pressure applied in steps until leakage occurred at 650 psi. At 300 psi the average stress through the bolt had, due to bending from flange rotation, decreased to 34,200 psi or a load of 10,300 lb. At this bolt load, assuming it constant, leakage should occur theoretically, at about 648 psi internal pressure.

Next step in the stress analysis of the pressure vessel is the investigation of the flange stresses and the vessel wall stresses, particularly at the weld fillets attaching the girth flanges to the shell wall. Bolt loads, being applied at a distance from the shell wall, force the flanges to rotate about a pivot point that

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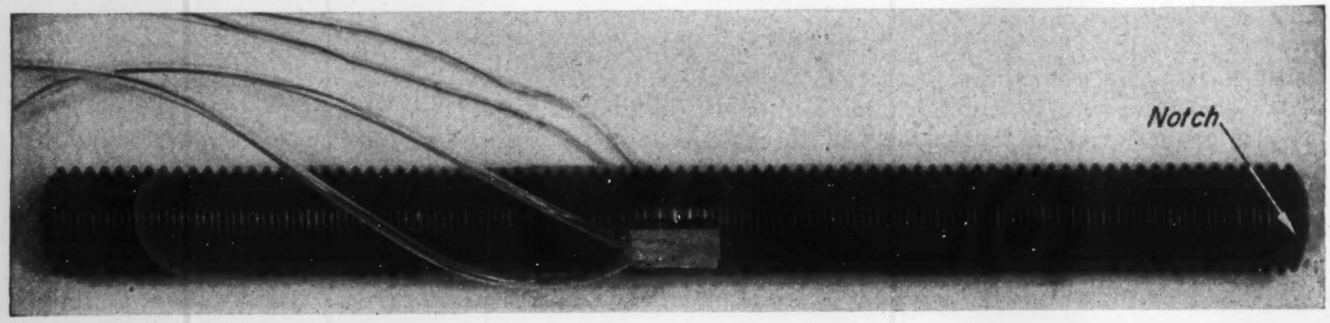
* References are tabulated at end of article on Page 128.



may be assumed to be the center of gravity of the radial cross section of the flange itself, point O in *Fig.* 5. The rotation of the flange causes the lower fibers to move toward the center of the tank and the upper fibers to move away. If the flange rotates through an angle θ then the strain at any fiber is $e = \theta y/r$, giving the distribution of stress shown in *Fig.* 5.

According to Reference 2 the moments and forces as shown in *Fig.* 5 may be determined using the following formulas:

$$M_o = RF\left[\frac{1}{1+\frac{Bh}{2}+\frac{1-\mu^2}{2Bc'}\left(\frac{h}{h_1}\right)^3 ln\frac{d}{c}}\right]$$

$$M_t = \frac{c'}{a}\left(RF - M_o - \frac{P_o h}{2}\right) = \frac{c'}{a}\left(RF - M_o - M_o\frac{h}{2}B\right)$$

$$M = M_t a$$

$$f = \frac{12My}{h^3\ r\ ln\frac{d}{c}}$$

$$\theta = \frac{M_o}{2BD}$$

$$B = \sqrt[4]{\frac{3(1-\mu^2)}{c^2 h_1^2}} = 0.58 \text{ for this case}$$

$$D = \frac{E h_1^3}{12(1-\mu^2)} = 144{,}700 \text{ for this case}$$

where

M_o = Torque per unit length of ring gasket centerline resulting from shell wall bending reaction (lb-in/inch)

M_t = Torque per unit length of flange centerline; i.e., locus of points O (lb-in/in)

M = Bending moment acting on the flange in a plane perpendicular to the plane containing M_o. M causes the stresses f_t and f_c shown in *Fig.* 7 (lb-in)

θ = Angle of flange rotation (radians)

a = Distance from tank centerline of flange centerline = 14.375 in.

R = Total clamping force divided by the circumference of the gasket ring centerline, equals $36 \cdot 10750 / 2 \cdot \pi \cdot 13.375 = 4610$ lb/in.

F = Distance between assumed center of bolt load Q, and center of clamping pressure assumed to be at the centerline of the gasket ring = 1.40 in.

d = Distance from tank centerline to outer edge of flange = 15.625 inches

h = Height of flange = 2.68 inches

h_1 = Wall thickness of vessel = 0.375-inch

r = Radius from tank centerline to any differential area on the flange cross section (inch)

f_t = Tension stress (psi)

f_c = Compression stress (psi)

μ = Poisson's ratio = 0.30 for steel

E = Young's modulus = $30\ (10)^6$ for steel (psi)

c = Distance from tank centerline to inner side of wall = 13.125 in.

c' = Distance from tank centerline to center of gasket ring = 13.375 in.

Substituting in the foregoing formula for M_o,

$$M_o = 1167 \text{ lb-in/in.}$$

Similarly the torque per unit length of the flange centerline, M_t may be calculated:

$$M_t = \frac{13.375}{14.375}\left[4610\ (1.40) - 1167 - \frac{1167\ (2.68)\ 0.58}{2}\right]$$

$$= 4070 \text{ lb-in/in.}$$

The outside fiber stresses on the shell wall resulting from the tightening of the flange bolts to 100 lb-

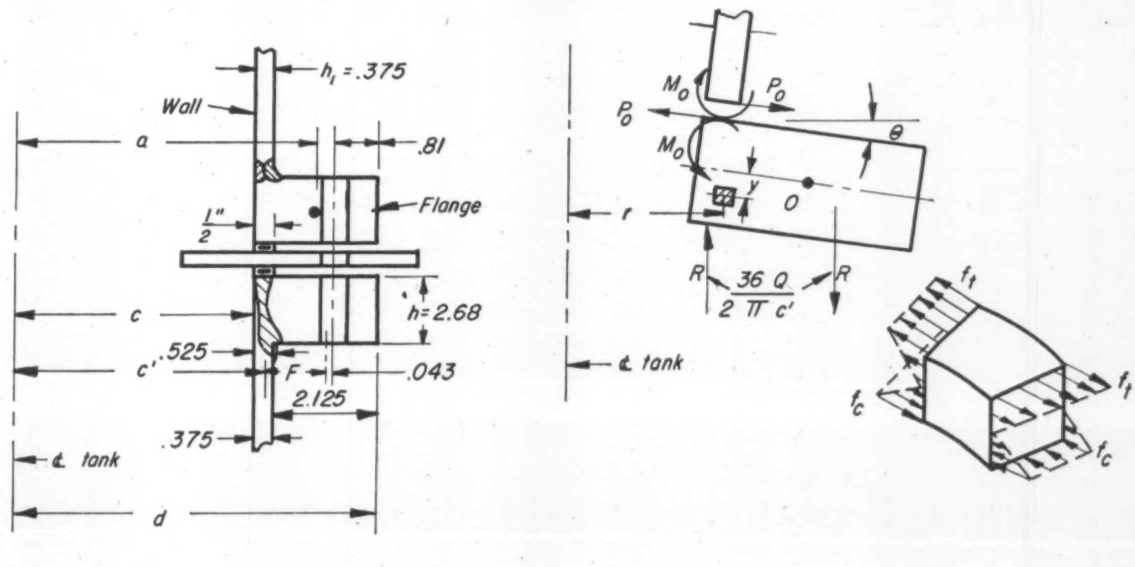


Fig. 5—Sketch of flange design, showing weld design, moment forces, and stress distribution

ft of torque may now be calculated. The section modulus is

$$Z=\frac{l\ t^2}{6}=\frac{1.0}{6}(0.525)^2=0.0458\ \text{ in}^3/\text{in.}$$

From this may be calculated the unit fiber stresses,

$$f_v=\frac{c'}{13.312}\ \frac{M_o}{Z}=\frac{1.002\ (1167)}{0.0458}=25{,}400\ \text{ psi}$$

$$f_h=\frac{12M_tay}{h^3r\,ln\frac{d}{c}}=\frac{12\ (4070)\ (14.375)\ 1.34}{19.2\ (13.5)\ 0.174}=20{,}850\ \text{ psi}$$

The wall fillet stresses are measured utilizing electric strain gages contrasted with calculated stresses in the sketch, *Fig.* 6.

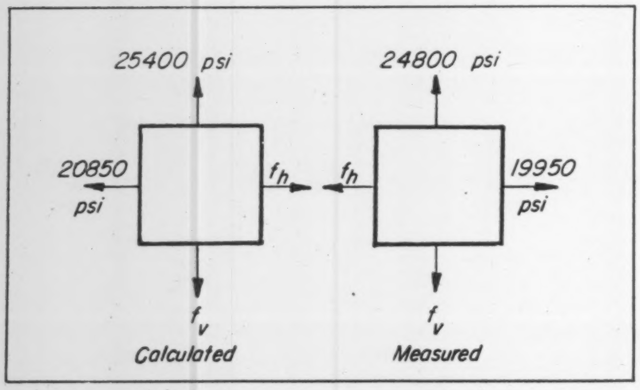


Fig. 6—Wall fillet stresses, comparing calculated with measured values using strain gages

It is of interest to compare the flange stresses on the outside corners as calculated with the measured stresses utilizing the strain gages shown in *Fig.* 2. The flange stresses are calculated for the condition wherein the bolts are tightened to 100 ft-lb with a bolt load of 10,750 lb:

$$f=\frac{12M_tay}{h^3r\,ln\frac{d}{c}}=\frac{12\ (4070)\ (14.375)\ 1.34}{19.2\ (15.625)(0.174)}=18{,}000\ \text{ psi}$$

The measured stresses for this condition range from 8800 psi to 12,100 psi.

If the center of pressure of the gasket is essentially at the same point as the mid thickness of the wall, under internal pressure the fillet stresses may be determined by adding the biaxial wall tension stress as determined by simple thin wall theory to the stresses already determined for the condition of bolt tightened only.

Results of this study indicate that theoretical flange stresses are in reasonable agreement with those measured on an actual vessel. It should be borne in mind that on this tank the bolt moment arm F varied somewhat as the edge distance in *Fig.* 5 fluctuated from 0.75 to 1.0 inch from bolt to bolt. The dimensions in *Fig.* 5 were measured in the vicinity of the bolt pictured in *Fig.* 4 but nevertheless the influence of adjacent bolts affects the fillet stresses measured at the point opposite the strain gage equipped bolt.

Thread friction is an item of great importance as can be seen from the formulas for bolt tension. The entire sealing ability of the tank and the resulting fillet stresses are a direct function of the friction coefficient. In the case of this analysis the choice of a value of 0.111 was fortuitous.

The center of pressure of the bolt tension was calculated from observed bending stresses. In this case the relative elasticities of the flange and bolt were such that very little center of pressure movement occurred.

It should be noted that in the equations involving the solution for the wall moment M_o, the nominal thickness of the wall $h_1 = 0.375$-inch is used whereas in the solution for the local stress in the wall at the flange fillet the local thickness of 0.525-inch is used; this is due to the fact that M_o is a function of the overall wall rigidity whereas the stress is a function of the local wall thickness, i.e., section modulus.

From the study it can be seen that there is no structural advantage favoring the more costly code-approved type of weld over the simple butt weld shown in *Fig.* 5.

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1. *Elements of Machine Design*—O. A. Leutwiler, McGraw-Hill, New York, 1917, First Edition, Fourth Impression, Pages 95 and 107.
2. *Strength of Materials*—S. Timoshenko, D. Van Nostrand & Co., New York, 1941, Part II, Second Edition, Fourth Printing, Pages 177-181.

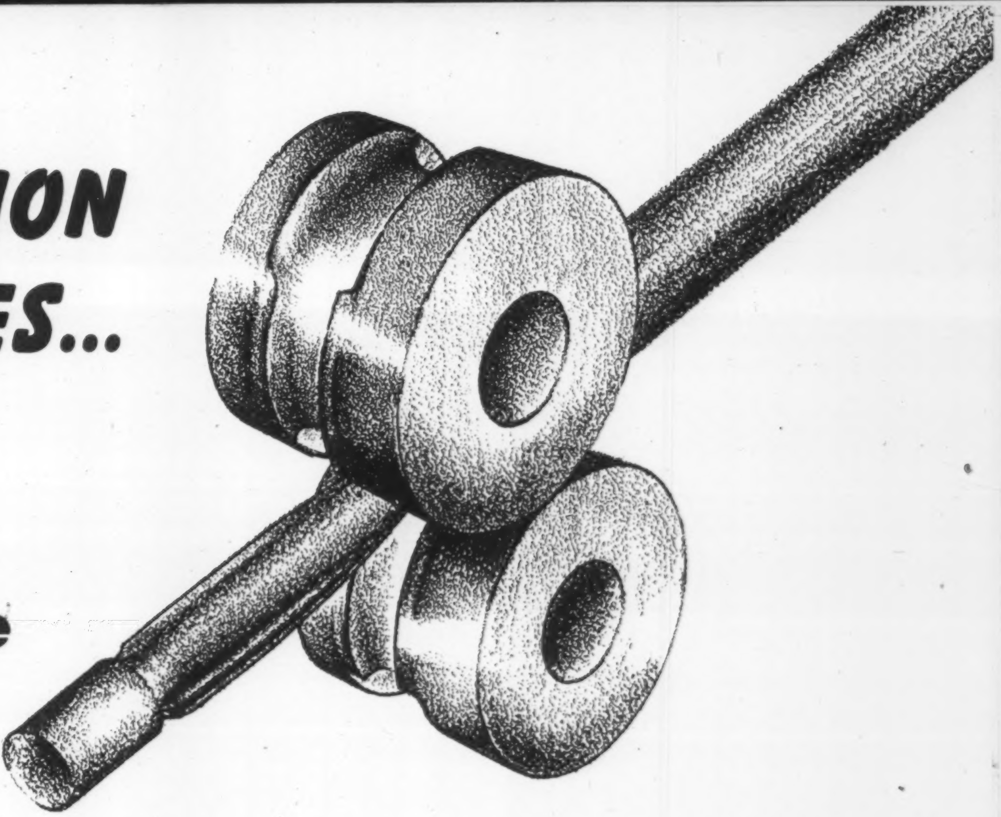
Revises System of Tempers

RAPID metallurgical advances and improved fabricating techniques during the past few years have served to magnify the inadequacies of the present temper designation system for aluminum and aluminum alloys. One example of how the present system is unable to fulfill present requirements is found in alloy 24S, the most widely used wartime aircraft material. Government specifications recognize the fact that 24S-T flat sheet has higher properties than may result from heat treating a formed 24S-T part. Under the present system, however, designers have no way of distinguishing on the drawing boards what kind of 24S-T they mean. Other examples requiring need for beter temper designation system are found in the other forms in which aluminum is fabricated, including extrusions, tubing, wire, rod and bar, forgings, rivets and castings.

In order to overcome such inadequacies in the present system and also to provide a definite pattern for future developments, a revised system of aluminum alloy temper designations has been developed by Aluminum Co. of America, Pittsburgh. This new system, based on manufacturing techniques, becomes effective on all company's product shipments made on and after Jan. 1, 1948. Presentation of these new temper designations is available from the company in booklet form.

PRODUCTION PROCESSES...

Their Influence On Design



By Roger W. Bolz

Associate Editor, Machine Design

Part XXIX–Roll Die Forging

PERHAPS least well known among the various forging methods is the process of roll-die forging often referred to by the trade as die rolling. An offshoot of the regular mill technique of hot rolling, die rolling offers the maximum in production speed, quality and low cost on machine parts which fall within its scope.

Unlike ordinary hot-rolling methods where multiple passes are employed to reduce a billet to the desired section, die rolling is limited to one stand or pass. Because it is impossible to enter a previously die-rolled bar so that it matches the impressions in the rolls for a second reduction, the process is in reality a finishing roll pass. Much as in ordinary rolling, also, die rolling is carried out with full length bars, eliminating much of the handling problem normally encountered in forging operations.

Inherently fast, die rolling is well adapted to the production of preformed blanks for subsequent forging in closed impression dies or of parts which require only subsequent finish machining operations. Most widely used at present for preforming forging blanks, this method eliminates almost all except the final one or two drop-forging operations, brings the blank to the final die impression much hotter, improves grain structure through better working of the metal, and increases forging output tremendously. The blank produced for forging a crankshaft and the forged crankshaft are shown in *Fig.* 1 while the blank for a camshaft is shown in *Fig.* 2.

Of primary interest to the machine designer, however, is the value of die rolling as a fast, efficient means for producing

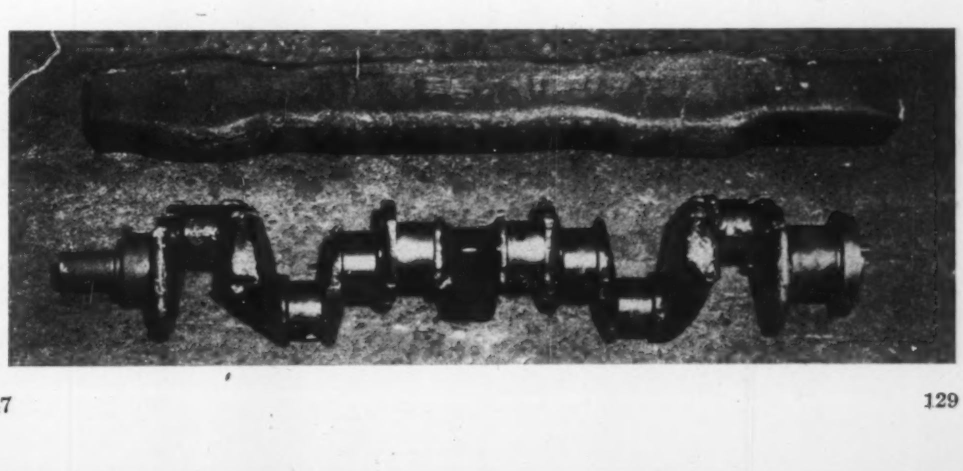


Fig. 1 — Right — Complicated forgings like this crankshaft are produced with greater ease and better quality from die-rolled blanks, one of which is shown above

Fig. 2—Right—Intricate engine camshaft forged from a special die-rolled blank shown at bottom

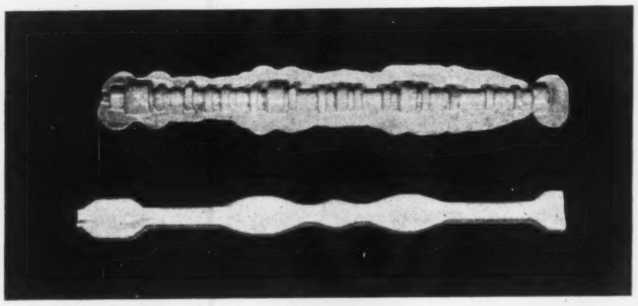
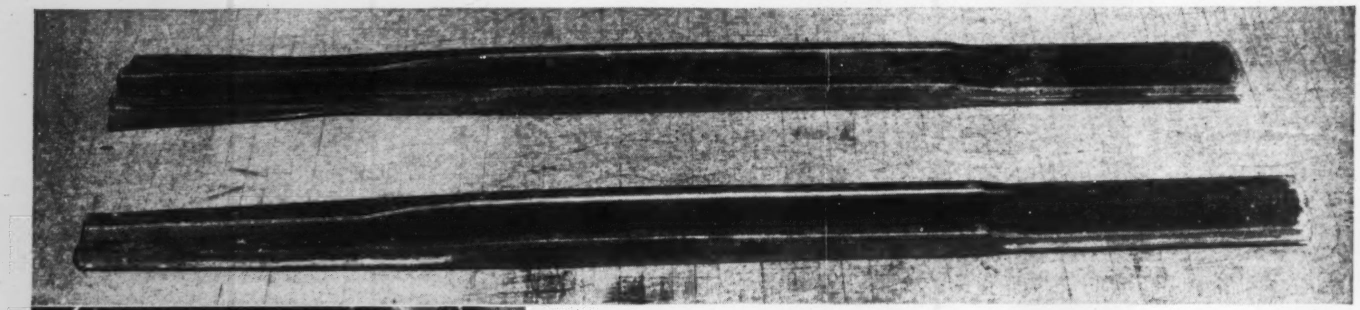
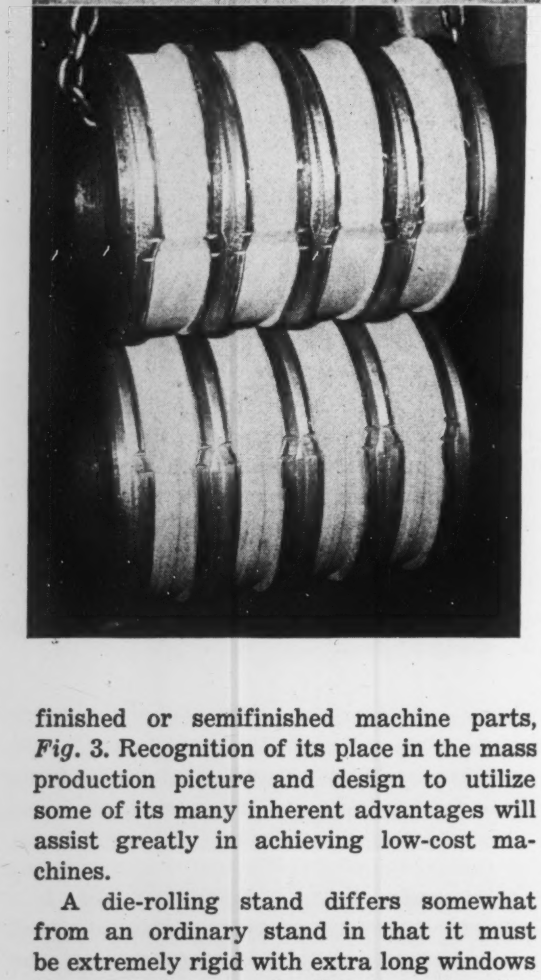


Fig. 3—Below—Light plow beam finished complete except for bending to shape, and set of rolls used for production die rolling these parts in quantity





finished or semifinished machine parts, *Fig.* 3. Recognition of its place in the mass production picture and design to utilize some of its many inherent advantages will assist greatly in achieving low-cost machines.

A die-rolling stand differs somewhat from an ordinary stand in that it must be extremely rigid with extra long windows to permit the use of rolls of varying diameters, it must have special fixtures to accommodate these various rolls, the drive arrangement must have variable speed, those in use today ranging from 20 to 60 rpm, and the roll gearing must be such as to allow accurate registration of the impressions in the rolls. Rolls used at present are usually from 16 inches in diameter to a maximum of about 32 inches. Impressions to suit the design required are machined circumferentially about the rolls, side by side, as many as the part width allows, *Fig.* 4.

Length of the part determines the number of identical impressions to be sunk in one circular impression. Short parts have multiple impressions while long parts often allow no more than one. Present equipment with 32-inch rolls allows for rolling of parts up to 96 inches in length although to date the longest part produced measures 75 inches in length and weighs about 330 pounds. Smallest part rolled measures about 1½ inches in length and weighs about 1¾ pounds. Maximum cross-sectional area which can be handled is about 23 square inches. In calculating roll grooves the dimensions of a part must be figured to hot size, allowing about 0.015-inch per inch for shrinkage on cooling. In rolling the largest sections and rolling from a large reduction to a small reduction, a groove somewhat longer than the part is required owing to slippage in the rolls commonly referred to as contrusion. For sections running from a large area of small reduction to a small area of large reduction and straight sections of large reduction, the groove must be made shorter than required for the part owing mainly to forward slippage of the metal or extrusion.

In operation, a preheated billet is reduced by ordinary rolling methods in several passes to form a leader bar similar in shape and possibly about 16 to 20 per cent larger than the largest section of the part to be die rolled. From the last stand this leader bar passes into the die rolling stand and emerges therefrom as a string of parts, *Fig.* 5. Strings of rolled parts may run up to as much as 135 feet in length and, being accurately spaced along the bar, can be cold sheared to proper length rapidly.

No upsetting of the metal takes place at any time in die rolling. As in plain rolling, working of the metal is entirely a matter of reduction. Reductions however, can be extremely severe *Fig.* 6, and can range up to as much as 75 per cent without complications. Largest reduction produced up to the present time has proved to be about 77 per cent.

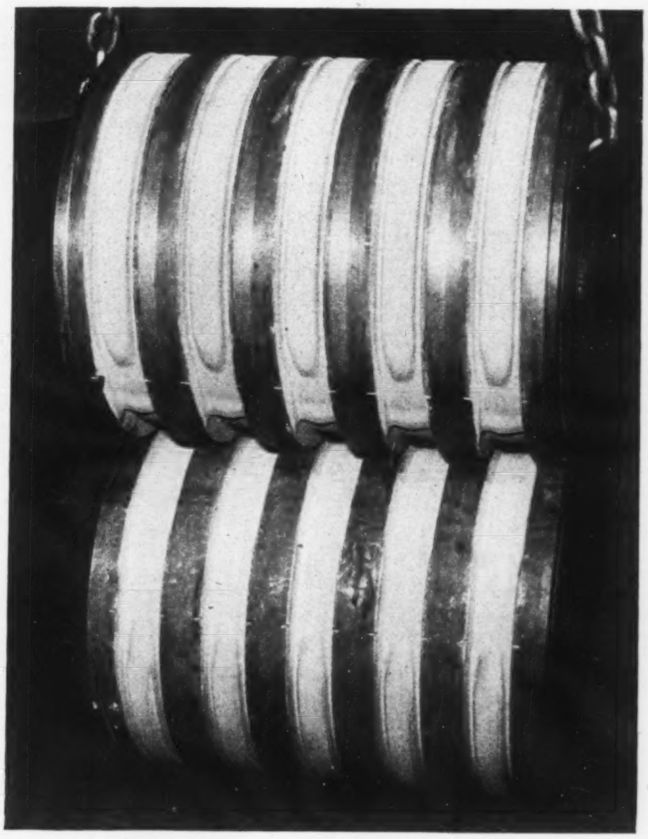


Fig. 4—Set of roll dies, with five impressions, for producing a die rolled automobile axle blank

Both flash and flashless parts can be readily rolled but reductions on flashless blanks are limited to a maximum of 48 per cent as against 77 for flash blanks. Too, flashed articles can be rolled to close tolerances owing to the fact that the metal is completely confined within and fills the roll grooves at all times, excess metal at points of reduction being squeezed out as flash. With flashless rolling, however, though the bar is within the grooves at all times, it never crowds the edges, no flash is formed and the part is smooth. Necessarily, therefore, the metal does not always completely fill the die impressions and much greater tolerances are required for such parts and use is primarily for forging blanks.

Being strictly a mass production process, die rolling quantities must be large in order to obtain the economical advantages available. Ordinarily a minimum quantity on light articles would range around 100 to 200 tons while for heavy or large parts this would increase to around 600 to 800 tons for an economical rolling. Gun barrels, for instance *Fig.* 7, are rolled at a rate of about 20 to 22 tons per hour with about 40 to 42 barrels in a string. Automotive front axles, *Fig.* 8, being larger are rolled at a somewhat slower rate in number of pieces but by weight at a rate of approximately 40 tons per hour. About 250 tons of axles can be produced before redressing of the rolls is necessary. After one redressing the roll grooves ordinarily must be resunk.

Of interest along with die rolling is the somewhat

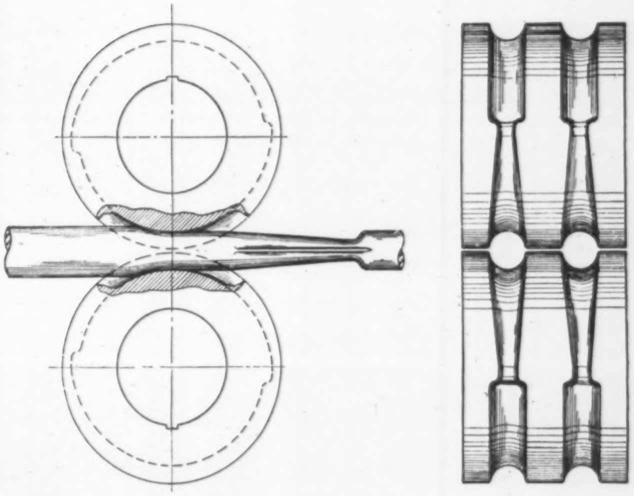


Fig. 5—Above—Leading rear axle blank emerging from roll dies. As one die groove wears, rolling is shifted to the next unworn groove

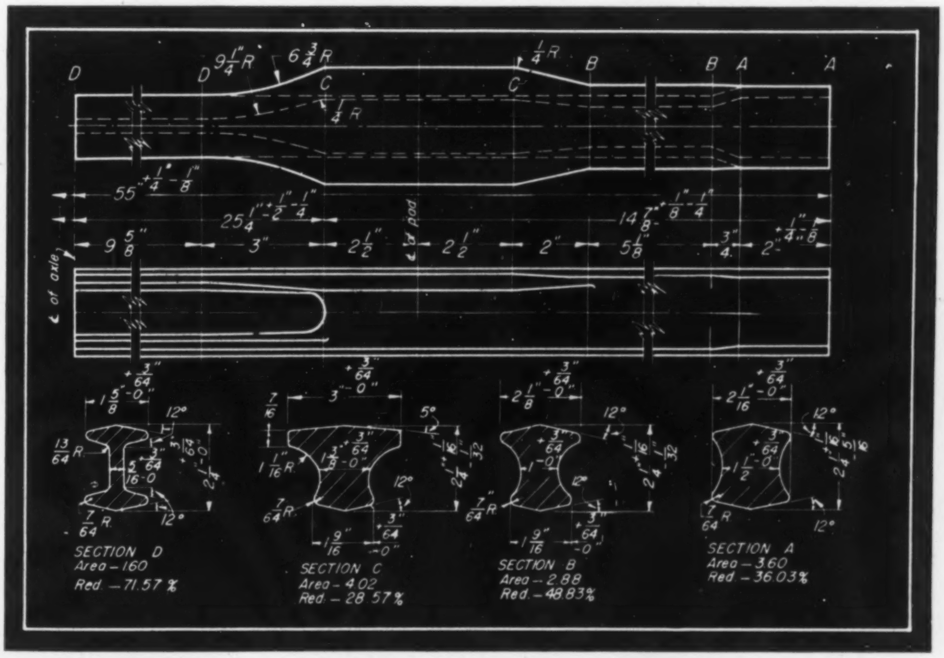

D
D
$9\frac{1}{4}$" R
$6\frac{3}{4}$ R
C
$\frac{1}{4}$ R
C
$\frac{1}{4}$ R
B
B
A
A
55" $+\frac{1}{4}"-\frac{1}{8}"$
$25\frac{1}{4}"+\frac{1}{2}"-\frac{1}{4}"$
$14\frac{7}{8}"+\frac{1}{8}"-\frac{1}{4}"$
$+\frac{1}{4}"-\frac{1}{8}"$
$9\frac{5}{8}"$
3"
$2\frac{1}{2}"$
℄ of pad
$2\frac{1}{2}"$
2"
$5\frac{1}{8}"$
$\frac{3}{4}"$
2"
℄ of axle
SECTION D
Area – 1.60
Red. – 71.57 %
SECTION C
Area – 4.02
Red. – 28.57 %
SECTION B
Area – 2.88
Red. – 48.83%
SECTION A
Area – 3.60
Red. – 36.03%

Fig. 6—Left—Die rolled front axle blank for a commercial 3/4-ton truck

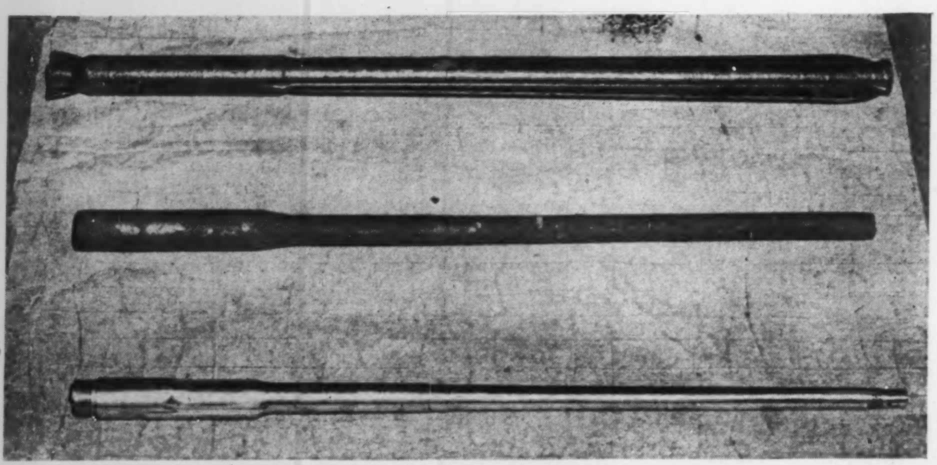


Fig. 7—Above—Garand gun barrels as-rolled, sheared and machined

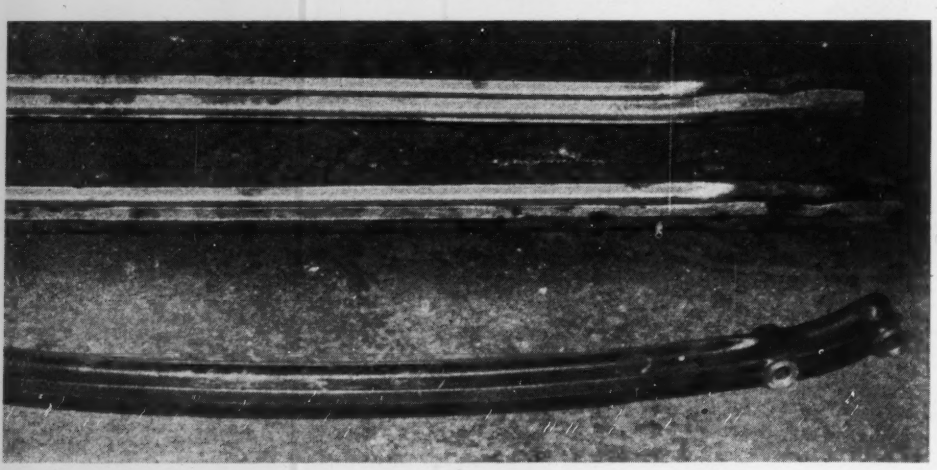


Fig. 8—Automotive front axle showing die-rolled blank at top and sheared blank at center. Finished axle shown below has been bent to shape, with opposite ends die forged to identical shape and machined

similar one known as gap mill forging. Performed on what is known as a forging roll, *Fig.* 9, flashless parts can be produced. Here, however, the roll dies are not continuous, the impression extends only over 50 to 75 per cent of the roll circumference and the remaining portion is cut away to form a gap for entry of the workpiece. Unlike die rolling the part is fed into the first impression and back, then rotated 90 degrees and moved to the second impression and back etc., in a step-by-step squeezing action, *Fig.* 10. Because of the intermittent operation, speed of the gap mill is necessarily slow and output lower than with die rolling.

Because the work is rotated about a longitudinal axis during forging, the gap mill process is limited to those parts having a symmetrical shape throughout. Any symmetrical cross section that can be turned 90 degrees in forging can be handled—such as a square part incorporating circular shoulders or necks. These, however, cannot be nearly as severe in reduction as with die rolling. As a rule, the minimum economical quantity of parts runs about 10,000 pieces. Smaller orders will not amortize mill costs.

Although definite advantages are

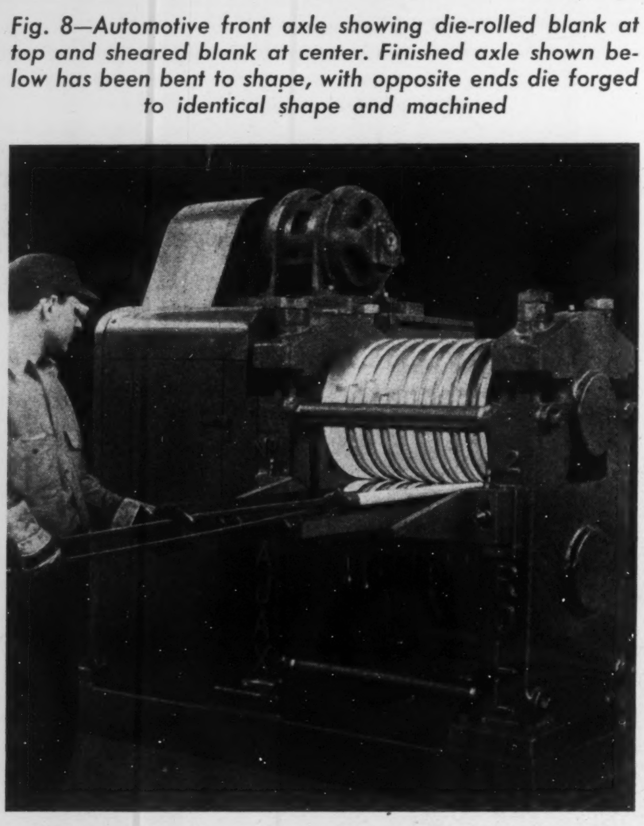
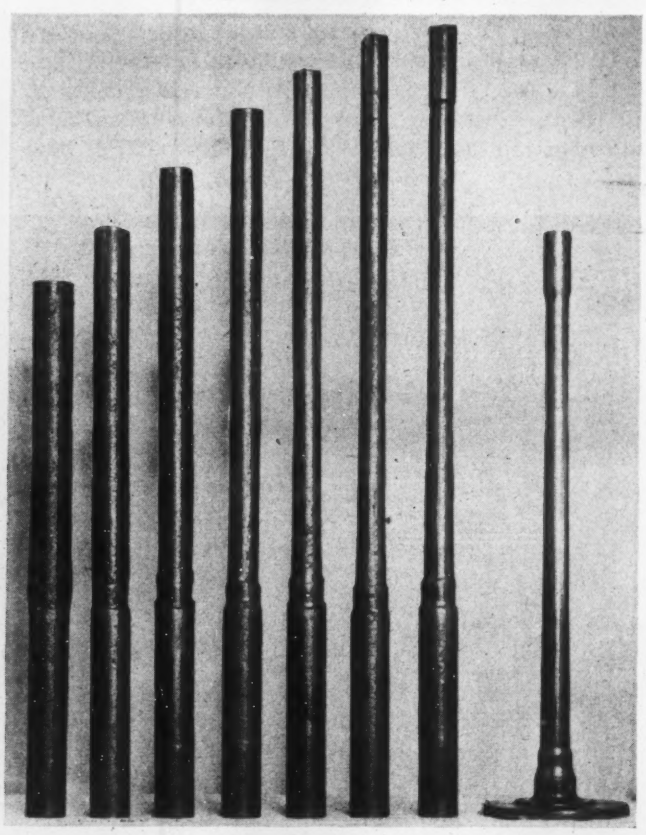


Fig. 9—Forging roll or gap mill utilized for progressive forging of flashless machine parts. Automotive rear axle is shown being produced

Fig. 10—Below—Progressive stages in gap mill forging a rear axle drive shaft. After one pass in each of seven roll grooves, it is straightened, sheared, upset and trimmed



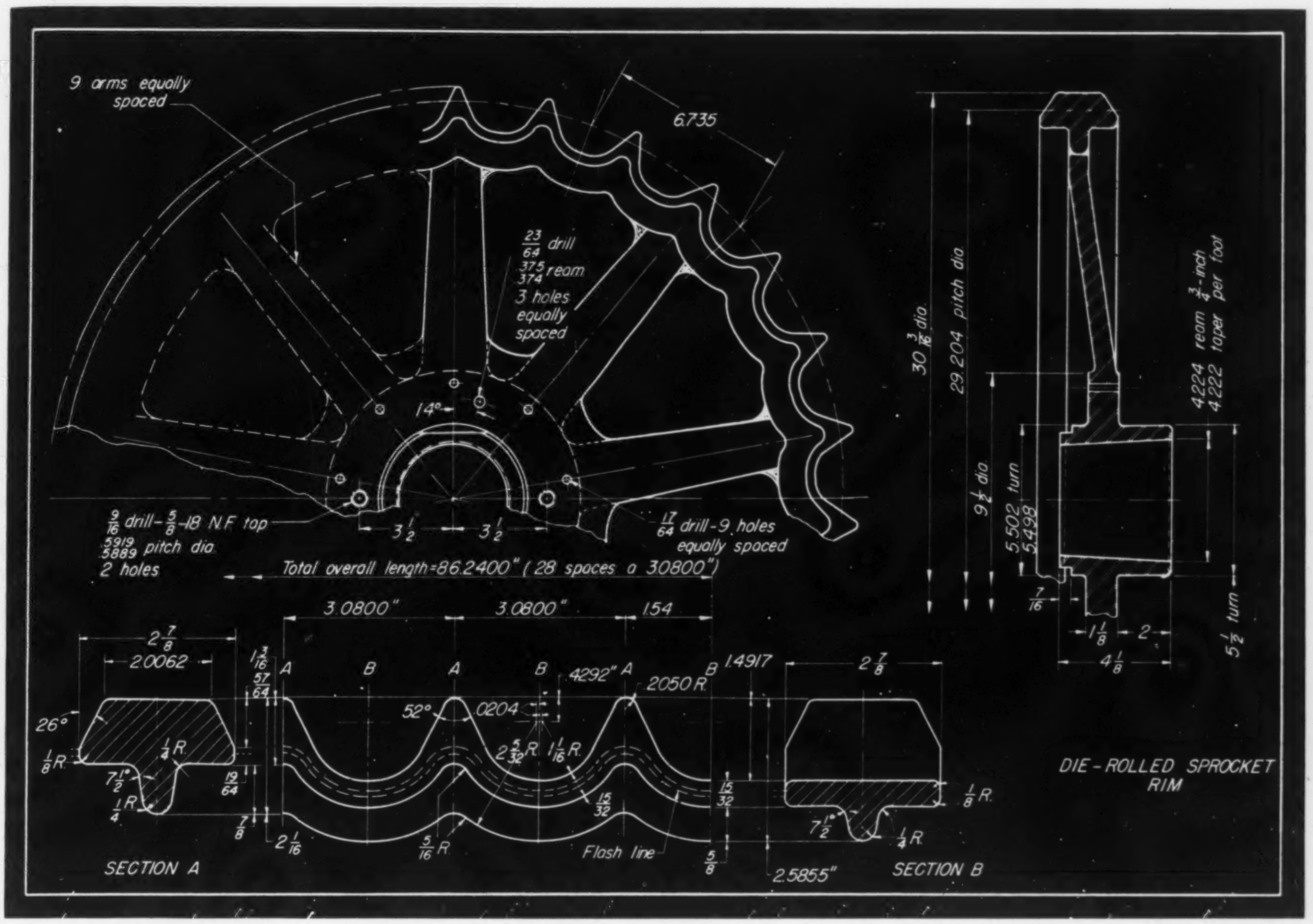

9 arms equally spaced
6.735
23/64 drill
.375/.374 ream
3 holes equally spaced
14°
9/16 drill-5/8-18 N.F. tap
5.919/5.889 pitch dia.
2 holes
3 1/2
3 1/2
17/64 drill-9 holes equally spaced
Total overall length=86.2400" (28 spaces a 3.0800")
30 3/16 dia.
29.204 pitch dia.
9 1/4 dia.
5.502/5.498 turn
4.224/4.222 ream 3/4-inch taper per foot
7/16
1 1/8
2
4 1/8
5 1/2 turn
3.0800"
3.0800"
1.54
2 7/8
2.0062
1 3/16
57/64
A
B
A
B
.4292"
A
B
1.4917
2.050 R.
2 7/8
26°
1/8 R.
1/4 R.
7 1/2°
1/4 R.
19/64
7/8
2 1/16
52°
.0204
2 5/32 R.
1 1/16 R.
15/32
5/16 R.
15/32
Flash line
5/8
1/8 R.
7 1/2°
1/4 R.
2.5855"
SECTION A
SECTION B
DIE-ROLLED SPROCKET RIM

Fig. 11—Track sprocket rim produced by die rolling indicates the unusual design possibilities of the process. Finished rim is subsequently bent into circular shape and welded to the hub section to form a completed sprocket

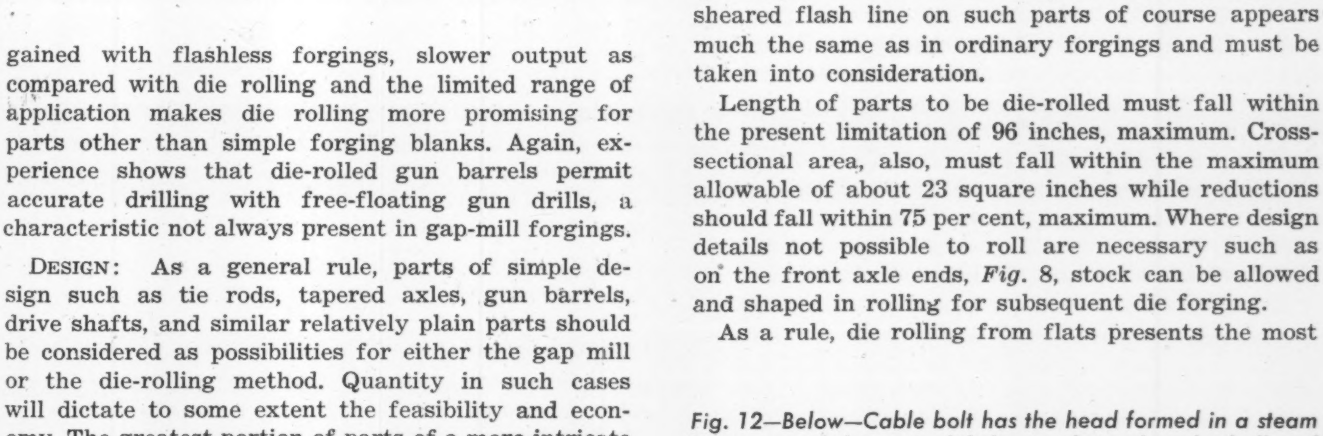
gained with flashless forgings, slower output as compared with die rolling and the limited range of application makes die rolling more promising for parts other than simple forging blanks. Again, experience shows that die-rolled gun barrels permit accurate drilling with free-floating gun drills, a characteristic not always present in gap-mill forgings.

DESIGN: As a general rule, parts of simple design such as tie rods, tapered axles, gun barrels, drive shafts, and similar relatively plain parts should be considered as possibilities for either the gap mill or the die-rolling method. Quantity in such cases will dictate to some extent the feasibility and economy. The greatest portion of parts of a more intricate nature which can be completed or nearly completed will naturally fall into the die-rolling category where quantity makes it economically feasible, *Fig.* 11. The sheared flash line on such parts of course appears much the same as in ordinary forgings and must be taken into consideration.

Length of parts to be die-rolled must fall within the present limitation of 96 inches, maximum. Cross-sectional area, also, must fall within the maximum allowable of about 23 square inches while reductions should fall within 75 per cent, maximum. Where design details not possible to roll are necessary such as on the front axle ends, *Fig.* 8, stock can be allowed and shaped in rolling for subsequent die forging.

As a rule, die rolling from flats presents the most

Fig. 12—Below—Cable bolt has the head formed in a steam hammer and the gear shift lever, above, has the ball end forged prior to completion on the gap mill



difficulty and from rounds or squares, the least. Therefore, substantially flat parts should be avoided wherever possible for maximum economy.

Radii specified on die-rolled parts should be generous especially where reductions take place along the length of parts. The minimum edge radii which can be held in production is 1/16-inch. Wherever possible 1/8-inch minimum radius is preferred. To simplify the rolling process generous draft should be allowed wherever possible. Minimum draft angles which should be specified range from 2 to 4 degrees on a side.

Ordinarily, abrupt changes in cross-sectional design permitted by die rolling cannot be handled with the gap mill. Where such part designs are necessary, the special features must be drop forged, *Fig.* 12, and the shank ends can then be completed by reducing in the forging roll.

MATERIALS: Various types of materials which can be handled in die rolling and gap mill forging naturally parallel those outlined in the previous articles on hot upsetting and die forging. Actually some metals which offer great difficulty in die forging, such as AISI-6412, present little difficulty in die rolling. These tough steels that resist proper breaking down and working prior to finish die forging are readily rolled into blanks that conform closely to the finished shape, simplifying the final forging operation. Such steels, too, can be readily handled as finished or semifinished die rollings.

Temperatures used in die rolling closely follow those employed in ordinary rolling practice. Highest temperature used is about 2100 F. Average steel parts are rolled at a temperature of about 1900 F with small parts running up to 2000 F and sometimes a little more.

TOLERANCES: In general, flashless blanks or parts cannot be held to close tolerances in die rolling and for obvious reasons their use as blanks does not necessitate the accuracy of finished or semifinished work. With flashless gap-mill parts, however, accuracy comparable to that of die forgings can be achieved and is satisfactory for parts which require subsequent finish machining on portions to be fitted.

In die rolling, average diameters can be held to plus 1/32-inch and minus 1/64-inch, *Fig.* 13. On large diameters, however, greater leeway is necessary and tolerances of plus 3/32-inch and minus 1/32-inch are normally employed, *Fig.* 14. Normal length and width tolerances for various sections can be readily noted from *Fig.* 6, 13 and 14. Tolerances on flash portions follow closely those outlined in the previous articles on die forging and hot upsetting.

Finish quality on both die-rolled and gap-mill forgings parallels that of hot-rolled upset and forged parts. Surface finish is suitable for most parts and as with any hot-worked material where extremely fine finish and close tolerances for fitted portions are necessary, machining operations must be employed as usual.

Collaboration of the following organizations in the preparation of this article is acknowledged with much appreciation:
Republic Steel Co. (*Figs.* 1 through 8, 11, 13 and 14) .... Cleveland
Crucible Steel Co. of America .... Midland, Pa.
Ajax Mfg. Co. (*Figs.* 10 and 12) .... Cleveland

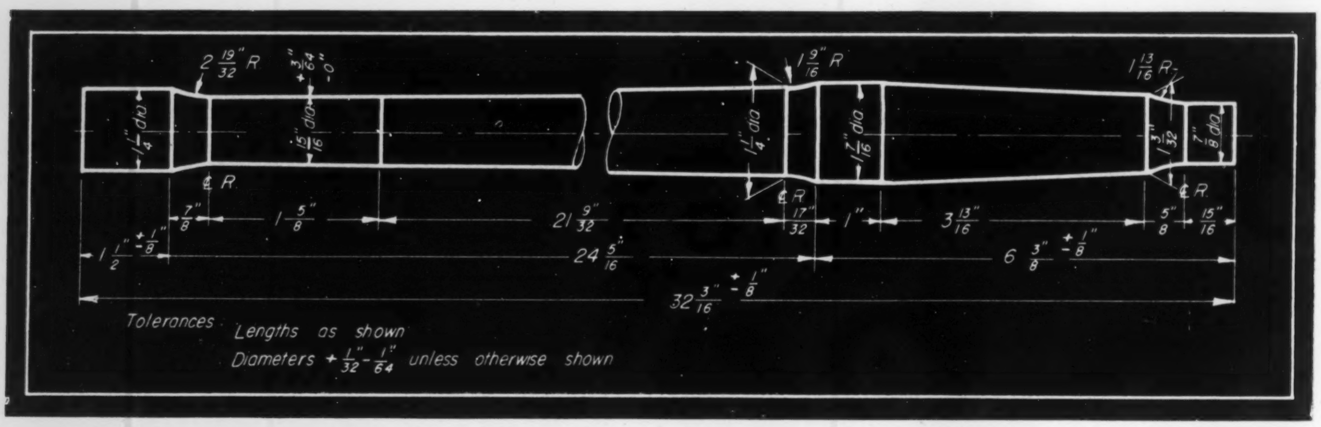

2 19/32" R
3/64" +0
1 1/4" dia
15/16 dia
¢ R
7/8"
1 5/8"
21 9/32"
1 1/2" +1/8" -
24 5/16"
1 9/16" R
1 1/4" dia
1 7/16" dia
1 13/16 R
3"/32
7/8" dia
¢ R
17/32"
1"
3 13/16"
5/8"
15/16"
6 3/8" +1/8" -
32 3/16" +1/8" -
Tolerances
Lengths as shown
Diameters + 1/32" - 1/64" unless otherwise shown

Fig. 13 — Above—Automotive rear axle shaft, die rolled from 8640-H steel, illustrates tolerances held on average diameter work

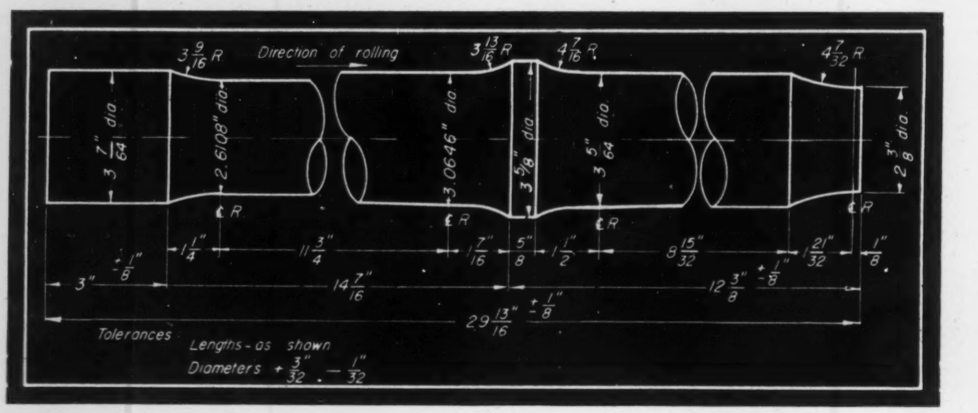

3 9/16 R
Direction of rolling
3 13/16 R
4 7/16 R
4 7/32 R
3 7/64" dia
2.6108" dia
3.0646" dia
3 5/8 dia
3 5/64 dia
2 3/8" dia
¢ R
1 1/4"
11 3/4"
1 7/16"
5/8"
1 1/2"
8 15/32"
1 21/32"
1/8"
3" +1/8" -
14 7/16"
12 3/8" +1/8" -
29 13/16" +1/8" -
Tolerances
Lengths - as shown
Diameters + 3/32" - 1/32"

Fig. 14—Left—Rear tractor axle, die rolled from SAE 3140 steel, showing tolerances held in rolling large diameters

Slant Mechanisms—Principles and Application

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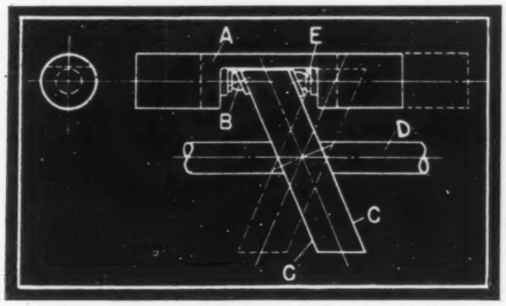


Fig. 1—Basic Michell-Crankless engine mechanism from which subsequent slant mechanism designs have been developed

FROM time to time, more or less serious attempts have been made to design engines of more compact shape in which the utilization of space is a definite objective. Mostly these fall into the class of what are frequently referred to as "round", "barrel", or "revolver" engines. In barrel-shaped engines the cylinders are arranged parallel to and surrounding the main shaft. Generally, the mechanism involves the action between a guided reciprocating element and a surface fixed to the shaft to be rotated. These constructions can be classified into two general types:

1. Those in which the working surface attached to the main shaft lies completely in a plane arranged obliquely to the axis of shaft rotation
2. Those in which the surface is a cam-shaped track formed to suit the motion desired.

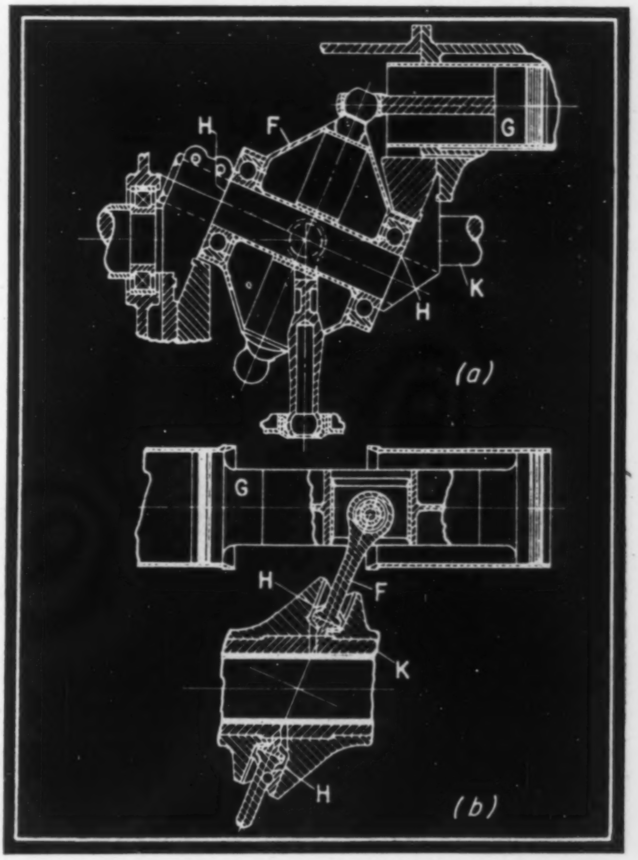
This article in particular concerns engines of the first type. The cam engines, type 2, have similar limitations to ball and roller bearings and are most suitable for small pumps, variable-speed hydraulic mechanisms in the small sizes, maybe small gasoline engines, etc. The author does not consider them suitable for "man-sized" engines or machines.

BASED ON a recent SAE paper, this article recounts the difficulties and successes experienced in applying the slant principle to a new lightweight aircraft diesel engine

One of the best known mechanisms of the kind under consideration (the first type) is the Michell-Crankless, the invention of A. G. M. Michell of Melbourne, Australia. This consists basically of a guided reciprocating piston unit *A, Fig.* 1, engaging by means of universally mounted slipper elements *B* with flat surfaces *C* obliquely disposed to the axis to power shaft *D*. The member containing the surfaces *C* is called a *slant,* which has become generally regarded as an apt descriptive name. This slant member is fixed on the main shaft and rotates with it. The hemispherical pivot surface on the back of the slipper element permits oscillation in the socket *E* and allows its flat bearing face to follow the varying presentation of the slanted surface.

Guidance of the reciprocating unit straight-line motion is effected by the circular walls of the cylinder. The success of such a mechanism depends on the efficiency (or absence of undue friction) of the slipper

Fig. 2—Two typical examples of wobble-plate mechanisms



element as a bearing on the slant surface and of the guidance. The slipper elements used are pivotally mounted unsymmetrically with respect to their flat segmental-shaped bearing surface and so are enabled to function in similar fashion to the pivoted pads in thrust bearings of the well-known Kingsbury or Michell type. Such slipper elements are able to accommodate themselves to the variables of load, speed and viscosity of lubricant and are probably the most effective bearings known. While detail difficulties arose from time to time in their practical application to Michell-Crankless machines there never has been a case where the magnitude of the frictional resistance of the slipper element was responsible for poor preformance.

The reciprocating unit in these machines has true harmonic motion. The combined kinetic energy of three or more equispaced units is of constant magnitude so that the total inertia effect may be likened to that of a flywheel. There is also the valuable consideration that perfect theoretical balance is obtainable since the moment of the mass acceleration of the pistons is of unvarying magnitude and can be accurately offset by choosing the dimensions of the slant member so that its product of inertia (tendency to set itself normal to the axis of rotation) is exactly equal thereto. This is a comparatively simple estimation.

The second general class of mechanisms coming within the type 1 classification are those frequently referred to as "wobble-plate" engines, *Fig.* 2. These involve the use of a nonrotating oscillating member *F* with which the piston elements *G* are connected. The oscillating member conveys the load applied by the piston to the obliquely disposed surfaces *H* attached to the main shaft *K*. It will be realized that there is tremendous scope for ingenuity in the means for attachment of pistons to the oscillating part, the form of the latter and in the type of bearings proposed for coaction with the slanted surface. The records of the patent office provide ample evidence of the variety of constructions which suggest themselves to inventors.

In most cases the oscillating member is a star-shaped piece or assembly carrying the loads imposed by the pistons in cantilever fashion to a center boss containing the slanted bearing system. For small gasoline engines and other low-pressure machines there seems reason to believe that sufficient strength and stiffness of the oscillating member can be secured. The author is of opinion, however, that the loads imposed by diesel engines are too great for this type of structure. It will be noted that in these engines the oscillating member (wobble plate) is, from a dimensional standpoint, the major part in the mechanism. The slanted surface which performs the principal function in the motion conversion becomes restricted in dimensions and is frequently much disguised. Furthermore, the leverage involved increases materially the magnitude of the loading applied to the obliquely disposed bearings. Many of the mechanisms proposed involve the use of ball or roller bearings which in themselves introduce speed and load limitations, particularly when the nature of the dynamic or shock loadings imposed by engines is considered.

Since the type of engine now known by the simple name "slant" originated in the Michell-Crankless system, it is of interest to look briefly through the changes in construction which took place during that development. Referring to *Fig.* 3, the simple arrangement shown at *a* was that used in the first M-C engine constructed (1922-23). This engine gave a good account of itself in competition with engines of its day but its shortcomings were always appreciated by the author, who designed it. Lubrication of the slipper elements was effected by jets of oil directed to the slant surface from the end walls of the slant

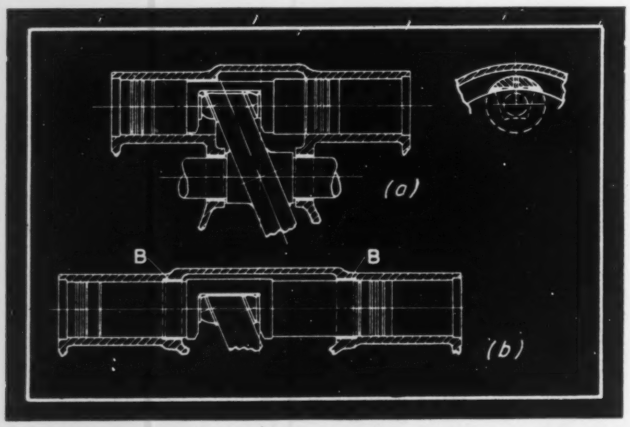
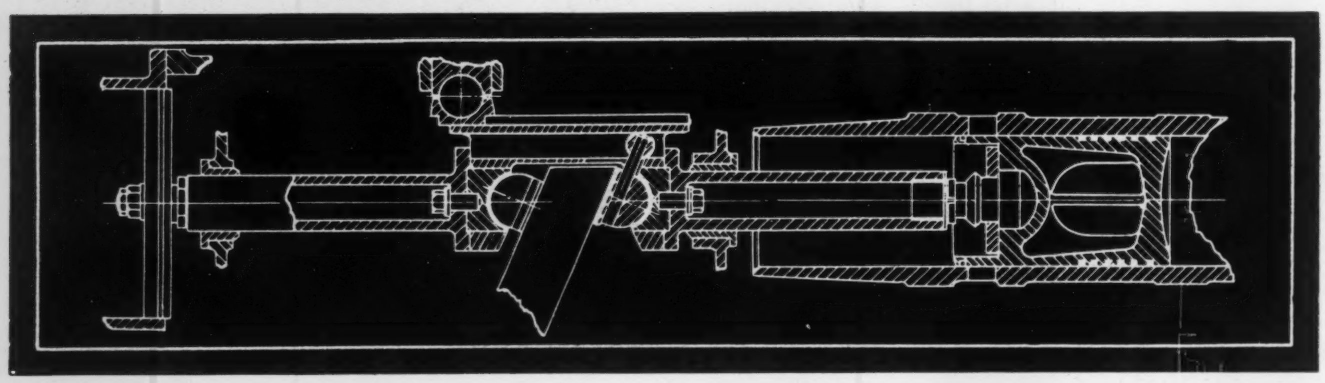


Fig. 3—Above—Two stages in the development of the Michell-Crankless engine, showing guide bush in view (b)

Fig. 4—Below—Original Michell-Crankless opposed piston engine mechanism. Right-hand piston is not shown, the unit at left being a scavenge piston



case. The result was the existence of a terrific oil storm within the close confines of the comparatively small chamber through which the reciprocating units moved. Prevention of overoiling of cylinders was a constant problem. When the cylinders overoiled, the mechanical efficiency was good, and vice versa. This engine always overoiled to some extent but in usable condition the friction of the cylinder wall guidance was excessive. The lateral reaction from slipper-slant coaction in the M-C system is an unvarying proportion of the load applied and so is much greater than the side loading carried by pistons in the connecting rod-crankshaft arrangement.

Immediately after this experience, two larger (industrial type) engines of identical size were put in hand. These were constructed in such a way that a comparison could be made between performance with and without the use of a guiding bush *B, Fig. 3b,* which could be amply lubricated and enabled the cylinders to be protected from direct exposure to slantcase conditions. The results were so favorable to the use of the bushing that it became standard practice on all engines thereafter. Bearing conditions in these bushings are favorable to low friction since the direction of load rotates uniformly, bringing about a combination squeeze-sliding action. By independent test, overall mechanical efficiencies of four-cycle engines as high as 93 per cent are on record.

Conventional Mechanism Is Stiff Competition

Despite many technical and operating successes, the introduction of this type of engine lagged until it became obvious that, considered as a direct replacement of the well-entrenched crankshaft system, the road ahead was too difficult. The different form of engine necessitated new arrangements of valve operating mechanism for the accepted poppet valve system and presented problems in accessibility which more than offset the compactness, balance, etc., offered by the Michell-Crankless system.

Looking over the engine field it was decided to apply the mechanism to a desired type of engine for which the crankshaft system was ill-fitted. The opposed-piston diesel engine was the choice. Experience with the first engine of this type proved it was necessary to free the piston proper from the guided reciprocating unit, otherwise ring troubles and head failures occurred. The engine was refitted as shown in *Fig.* 4 and ran more then 2000 hours on the test stand at Canton, Massachusetts.

Returning to *Fig.* 3*a* and the small detail at right, it will be seen that the area of the section of the reciprocating unit where it embraces the periphery of the slant, called the bridge, is a compromise between the size of the slipper pad and the stiffness required of this section to handle bending moments arising from lateral reactions from a slipper-slant coaction. In view of the fact that it is not practicable to provide a guiding surface on the slant side between ends of cylinders, the inward-directed reactions impose a considerable bending moment on the connecting portion.

Under the light loading of, say, an automobile type gasoline engine this compromise can be readily effected within the diameter of the piston. With diesel loading, however, larger slippers as well as greater bridge stiffness are needed. This forced an enlargement of the bridge section beyond the cylinder diameter and increased the overall length of the reciprocating unit, as indicated in *Fig.* 4.

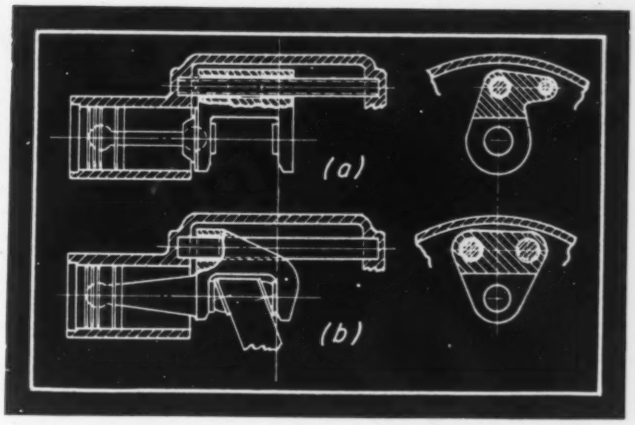


Fig. 5—Alternative means for providing adequate guidance of sliding member in single-ended slant mechanisms

In examining the application of the double-ended guided reciprocating unit to the opposed-piston machine, it will be seen that it has undesirable extension beyond the slantcase. At the front or scavenge end of the engine, these extensions may be used to mount pistons for pumping scavenge and charging air, *Fig.* 4. If this type of pump were not desired, these ends would be of no particular use. Consequently, attention became concentrated on what may be termed "single-ended" construction. The Sterling Engine Company adopted the arrangement shown in *Fig.* 5*a* for the engines which it manufactured and sold. The author prefers the scheme outlined in *Fig.* 5*b*. Both of these are "bridge-guided" or crosshead constructions involving the use of bars attached to the walls of the slantcase. Other methods of guiding the bridge end have been tried out without success. In retrospect it will be realized how far the development has departed from the original form of Michell-Crankless. This is by no means unusual in engineering developments but there always comes a time for a halt to be called and serious consideration given to the course ahead.

About this stage the author discussed with the U. S. Navy Department the design of an opposed-piston diesel aircraft engine of 2000-hp take-off capacity to weigh one pound per horsepower. The problem demanded a "stop, look and listen" attitude if the best results were to be achieved. The crosshead type of construction into which Michell-Crankless had gravitated was definitely out. The bridge end of the reciprocating unit was unduly heavy and the structure supporting the guidance also unwieldy. There was the further fact that the barrel type of engine was basically multi-cylinder yet practically all of the engines which had been built were of the four-cylinder pattern. Investigation indicated that at least eight and probably nine cylinders could be arranged within the same space requirement as the four. The essentials of two slants and one main shaft were a fixed condition independent of the number of cy-

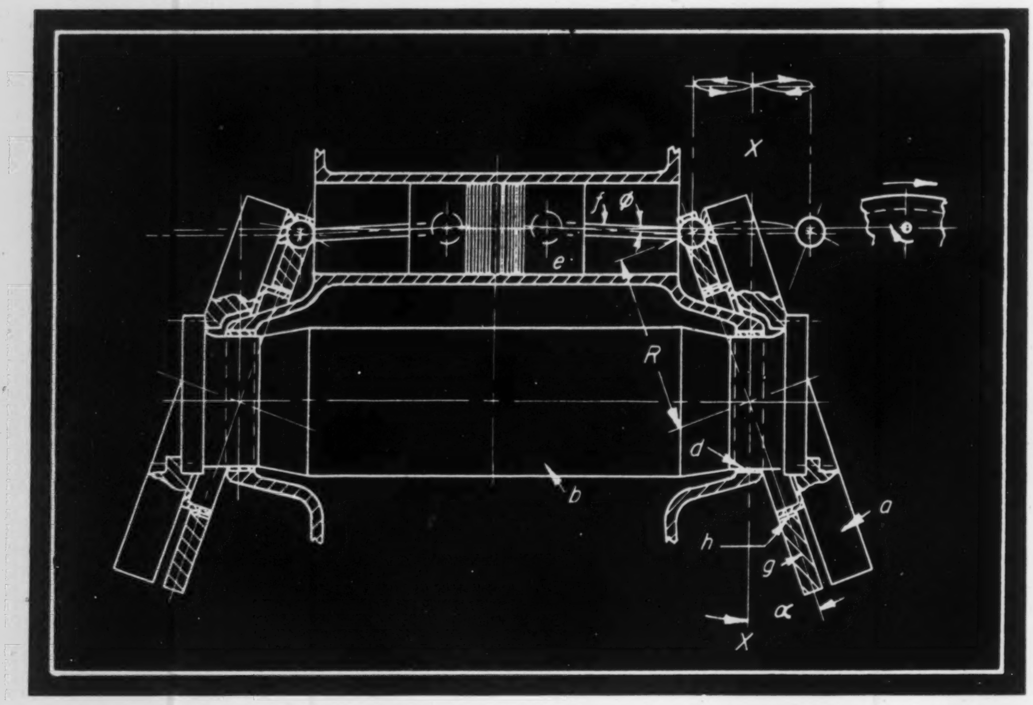


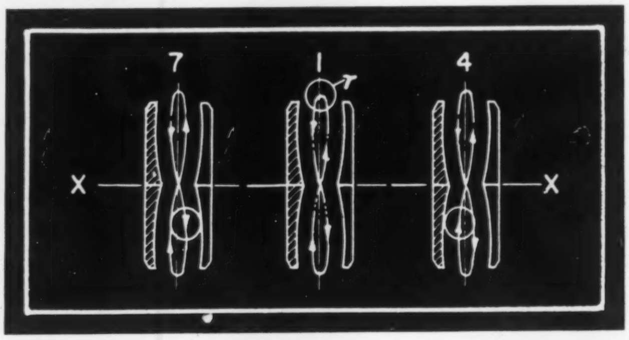
Fig. 6—Left—Basic slant-cage mechanism adopted for opposed-piston lightweight aircraft diesel engine

Fig. 7—Below—Torque reaction system using three equally spaced sets of guides

linders used. Length, also was not affected.

Finally it was decided to build an engine with nine equispaced cylinders serving 18 pistons of 6 inch diameter by 8 inch stroke, giving a displacement of 4070 cubic inches. A mechanical arrangement was decided upon which retained the good points of the Michell-Crankless system but avoided the individual crosshead construction. This consisted basically in the use of two slant plates *a, Fig.* 6, attached to the ends of a stiff tubular shaft *b* supported in two bearrings *d* only. Each set of pistons *e* was connected by short ball-ended rods *f* to a "cage" member *g* located on bearing *h* parallel with the inclined surface on the slant. The cage member has the same oscillating, nonrotating motion as a wobble plate but differs in that the piston loadings are transferred directly to the slipper-slant coaction with the cage, providing lateral guidance only. One cage therefore serves the same purpose as nine sets of crossheads. The reaction forces applied to the cage are comparatively simple, being always parallel to the surface of the slant as shown in *Fig.* 6 and combined with a tangential opposing reaction to the torque applied to the slant.

It is pertinent at this stage to examine briefly the dynamic conditions existing in such a construction. For true universal motion the locus of any point on the oscillating plane, when projected on to the normal plane *X-X* passing through the center of oscillation, describes a circle of diameter equal to $R\ (1-\cos^2\alpha)$ uniformly at twice shaft speed and in the same direction of rotation. The projection of this rotating point on a line tangential to the radial position has true harmonic motion. The summation of the directional inertia due to three or more equispaced harmonic motions is zero. Inferentially the total tangential effect for the whole symmetrical plate and the nine equispaced rod ends is zero and there is no resultant rotational inertia force. Since the cage is a symmetrical member about the center of oscillation, it can be readily observed that there are no unbalanced radial forces.



Inasmuch as the displacement of the center of the piston rod socket in cage from the center of the locus of its rotation movement, coincident with cylinder axis, is always constant, the angularity of the rod, ϕ, will never change. The projection of its length, therefore, on the cylinder axis will remain fixed and there will be no secondary effect on the motion of the piston by reason of piston rod angularity. The displacement S of the socket from the central plane *X-X* is equal to $R \sin \alpha \cos \theta$ (θ being the angle of rotation of the main shaft), so that the motion of the socket referred to the cylinder axis will be of simple harmonic character. The movements of all pistons are identical and equivalent dynamically to the Michell-Crankless system.

When oscillating in true universal motion, the moment of mass acceleration of the cage member is of constant magnitude and may be likened to a rotating slant but of opposite sign. Rotationally there are no changes in its inertia and consequently no effect whatever on the character of the torque curve.

In the actual engine it was decided to remove the effect of the oscillation of the piston rod ball end from the slipper pad pivot. To do this it was necessary to displace the rod socket from the center plane of the cage. This changes the shape of the locus of movement of the socket into approximately a large circle at inner and a small circle at outer end. Investigation will show no appreciable changes in rotational inertia of the cage system are involved and the effect on the basic harmonic motion of the pistons is negligible. If the two opposing piston and cage inertia systems were in phase, the engine balance would not be concerned with variations from the true harmonic so long as the motions of the pistons were identical. Only the out-of-phase effect of the irregularity need be considered, therefore, which makes it even more negligible.

In the balancing of the engine the shaft-slant assembly can be balanced on a dynamic balancing machine. This will also take care of the phase displacement of the slants. The moment of the mass acceleration of each piston, rod and cage assembly can be calculated accurately and correction for the phase displacement of the two systems obtained by the drilling of suitably-placed holes in the slant members after the slant-shaft assembly has been balanced. With the exception of the negligible rod effect, the balancing forces are of the first order and so may be completely balanced.

Unbalanced Condition Caused Trouble

As originally constructed, the cage member was located radially on a journal bearing attached to the slant as shown in *Fig.* 6, and the simple rotational control of a block sliding between flat plates attached to the bottom of the slant-case was adopted. This was done with knowledge of the unbalanced system which would result. The effect is similar to that produced in a Hooke's or Cardan joint. However, the cage member itself was comparatively light and it was figured that the forces could be handled. The test bed quickly disproved this contention since there occurred a very definite resonant condition within the range 1100-1200 rpm, which was destructive of the tangential control parts and of the mounting formed on the wall of the slant-case. Up to this speed and beyond, the engine ran smoothly, but since the resonant speed range could not be run through without trouble it was necessary to modify the construction so as to produce uniformity in the oscillation.

If a point on the central plane of the cage be observed in a radial direction looking inward toward the main shaft, the locus of movement is a lemniscate (shaped like ∞), *Fig.* 6. If the cage member were completely free of all friction and not subject to a torque reaction, it would float with all points following the locus described. Tangential control can therefore be effected by the provision of lemniscate-shaped guide plates coacting with a roller mounted on the cage. If such a cage be subjected to torque conditions, the guide plates will carry such torque reaction without permitting the cage to be forced from its desired natural movement.

The engine was then fitted with three equispaced sets of torque reaction plates, shown in flat development in *Fig.* 7, using only that portion of the lemniscate in each suitable for such purpose. It will be noted that the ends of the complete lemniscate are roughly circular. Since concern is only with tangential components no reaction in the plane of the cage is possible at dead-center positions. This arrangement proved more satisfactory than the flat guide but demanded great accuracy in manufacture and much compensation for possible cage movements laterally. The principal functional weakness lay in the fact that the roller *r* had to change its direction of rotation at each contact with a plate. At the higher engine speeds the arrangement proved impracticable.

The next arrangement tried out avoided the change in direction of roller rotation and simplified the accuracy problem. The scheme is outlined in *Fig.* 8. By using guide plates on only one side of the midplane of oscillation *X-X,* each roller contacted one guide surface only, always in the same direction. Related contacting of adjacent rollers only was involved so that there were no cumulative errors to be concerned about and lateral displacement of the cage had little effect. Nine equispaced rollers were fitted to the cage (i.e., adjacent to each piston rod socket). Referring to *Fig.* 8 it will be noted that at the instant roller 1 was at the end of its movement, the rollers 9 and 8 were in the positions indicated and carrying torque reaction. Rollers 2 and 3 were just free of the opposite guide plates used for motoring or reverse torque under light loads. As the motion proceeds, roller 8 will leave its guide and move out into space. Number 9 will carry on alone until number 1 picks up. It will be noted that for the 40-degree spacing of cylinders (or rollers) the roller is moving parallel to its guide plate when contact takes place. This gives a smooth pickup, so much so that when the engine is running not the slightest shock can be felt immediately behind the point at which contact takes

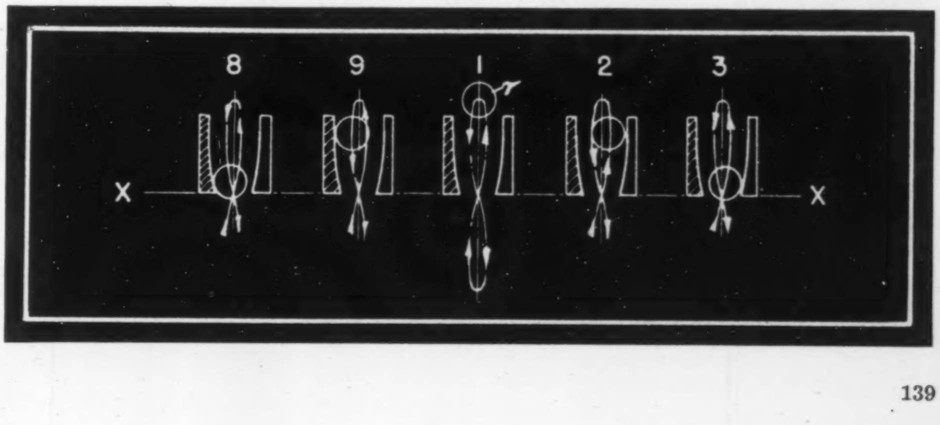
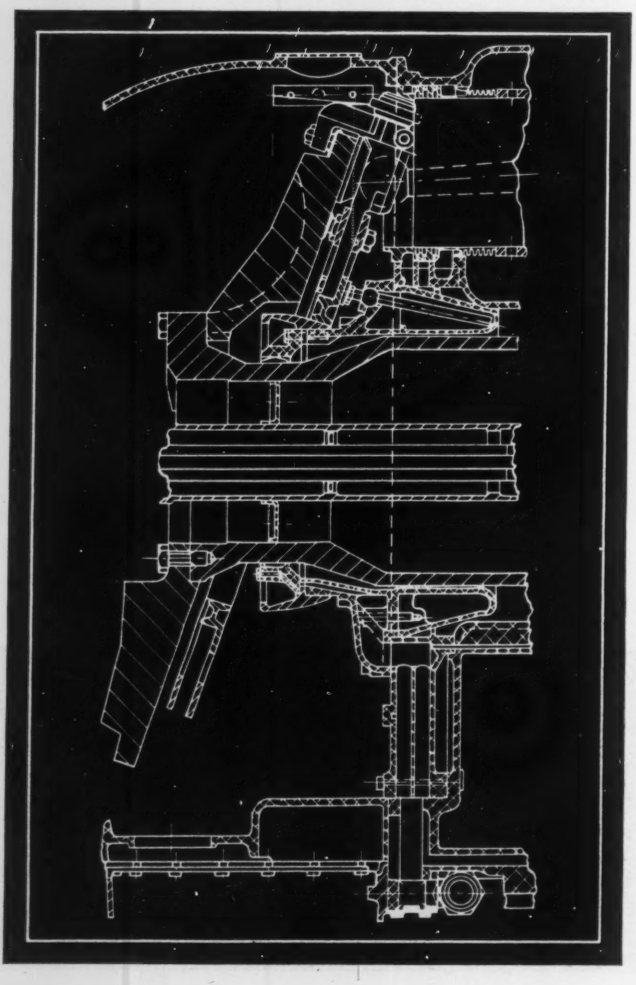


Fig. 8 — Torque reaction system as finally developed for opposed-piston aircraft diesel engine

place. The sound from these rollers when the guide plates are directly mounted on the slantcase wall (worst possible condition for noise) is of a whirring nature and is not noticeable in this aircraft type engine. In a commercial engine the guide plates can be much more favorably located.

This torque reaction system proved highly satisfactory and there have been no cases of direct roller trouble. The cage location bearing attached to the slant, however, was of large diameter and proved sensitive and unreliable at the higher speeds. After several modifications this was finally removed in favor of a fixed spherical mount as indicated in *Fig.* 9. This mount is now regarded as one of the most substantial detail developments and has done much to provide a very practicable, efficient construction. Its location of the cage is independent of shaft movements and has fixed, definite relation to the position of the torque guide plates. During assembly the cage can be held on this member in the plane normal to the shaft axis and indexing of rollers and guide plates checked in place. This is a valuable feature for large engines or where new guide plates or rollers are fitted in the field. Under operating conditions the reactions parallel to the slant surface applied through the cage to the spherical surface of the mount do not involve relative motion between the parts, there being merely a shift from point to point around the mount. The friction involved is therefore an absolute minimum. The tangential torque reaction load is only of the order of 3500 pounds in this engine and the roller transference is definitely a low-friction proposition. Owing to the small angles at which the piston rod operates, the side loads applied to the pistons are of negligible magnitude.

Fig. 9—Detail of the actual slant-cage construction, showing spherical mount design used in opposed-piston engine



In view of the low weight limitation, the slant members presented one of the most difficult design problems in the engine. No previous design practice as to minimum dimensions, stiffness, etc., existed. Since the load is transferred close to the perimeter any stiffening metal added in that vicinity brought about a rapid increase in total weight so there was a natural tendency to keep this at a minimum. There was also the desire to provide a hardened surface for the flat slipper track. The first slants were SAE 4620 steel, with carburized track. These lasted comparatively few hours before cracks appeared. For the next slants the sections close to where the major combustion load was applied were increased. The material was changed to SAE 4340 and the flat surface was flame-hardened to 50-55 rockwell C. Two of these slants performed very well and ran out the tests on the first engine. When the next two engines were put in hand the specification was repeated but none of the five slants made for them ran more than 20 hours before cracking. There then ensued a long fight to hold weight down and retain some hardness on the slipper track.

Difficulties of Slant Design

Looking back, it would probably have been wiser to have ignored the weight problem and retraced steps at a later date. However, as is frequent in such developments it was always felt that the solution was at hand. The time required to obtain material in war time (despite a good priority rating), and to machine and assemble took many months for every change. Many ideas were tried out, including chrome plating of slipper tracks, nitrided slipper tracks, shot blasting, various materials—SAE 4340, 3250 and 4820. In the case of chrome plating, the bonding was unable to cope with the flexure of the surface. The nitrided surface also spalled, although it might have been satisfactory with further annealing. Much was expected from shot blasting but one slant cracked after 6 hours running, the other at 45 hours. As is now known, the part had insufficient fatigue strength in the heavily loaded area. The piston load applied to the slant is of the order of 15 tons. These slants weighed from 125 to 150 lb each. Finally the slant weight was brought up to 175 lb and results have since been completely satisfactory. Two slants of SAE 4340, 36 rockwell C in the engine now on test stand have been in use for the past couple of years. Two others of SAE 4820 with gas carburized tracks have also stood up well. The problem was of course interrelated with that of the slipper pad. The necessity for specifying a hardened track also became of lesser importance.

The piston rod is mounted at both ends in spherical

(Concluded on Page 186)

Solution of Equations Simplified

... by following the routine procedure explained in this article. Roots of any high-degree algebraic equation may be found to any desired degree of accuracy

By Albert S. Goodrich Jr.
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HIGH-DEGREE algebraic equations frequently arise in stability, mechanical vibration and electrical oscillation problems. There may be six or eight complex roots along with the real roots, and the more common methods of solution may prove unsatisfactory. A powerful means of solving such equations is available in Graeffe's root-squaring method, which is the subject of this article.

By this method of solution neither graphing nor a predetermination of any of the roots is necessary. No matter what the combination of real and complex roots is, all can be determined immediately to any degree of accuracy. The procedure is routine and dependent on little theory.

The basic operation is the transformation of the original equation into a new equation whose roots are so widely separated as to be determinable individually. Considering the general equation

$$x^n+A_1x^{n-1}+A_2x^{n-2}+\ldots\ldots+A_n=0 \quad\ldots\ldots\ldots\ldots(1)$$

let it be assumed that the roots are real and unequal and, with their signs changed, designated by *a, b, c, d,* etc. These are called the "Encke" roots. Moreover, let $|a|>|b|>|c|>|d|$, etc. Now the relationships existing between the coefficients and roots of an algebraic equation may be expressed as follows:

> If the coefficient of the highest-degree term of an algebraic equation is unity, then the coefficient of the second highest-degree term is equal to the sum of the roots with the sign changed; the coefficient of the third highest degree term is equal to the sum of the products of the roots taken two at a time, etc.

Using these relationships, Equation 1 may be written

$$x^n+[a]x^{n-1}+[ab]x^{n-2}+[abc]x^{n-3}+\ldots=0\quad\ldots\ldots\ldots\ldots(2)$$

where $[a]$ denotes the sum of the roots *a, b, c,* etc., $[ab]$ denotes the sum of the products of the roots taken two at a time, etc. If $a^m+b^m+c^m+\ldots$ be represented by $[a^m]$, then

$$x^n+[a^m]x^{n-1}+[a^mb^m]x^{n-2}+\ldots=0\quad\ldots\ldots\ldots\ldots(3)$$

This is Equation 1 transformed so that its roots are the *m*th power of the original ones. Actually, it is convenient in the numerical computations to make this transformation with $m=2$ and to repeat this transformation several times.

If the original equation is squared after it has been rearranged to have all even power terms oppose all odd power terms,

$$(x^n+A_2x^{n-2}+A_4x^{n-4}+\ldots)^2=$$
$$-(A_1x^{n-1}+A_3x^{n-3}+A_5x^{n-5}+\ldots)^2\quad\ldots\ldots\ldots\ldots(4)$$

and if like terms are collected,

$$x^{2n}-(A_1^2-2A_2)x^{2n-2}+(A_2^2-2A_1A_3+2A_4)x^{2n-4}-\ldots=0\ (5)$$

Letting $y=-x^2$ in Equation 5 gives

$$y^n+(A_1^2-2A_2)y^{n-1}+(A_2^2-2A_1A_3+2A_4)y^{n-2}+\ldots=0.\ (6)$$

Because the roots of Equation 1 are $-a$, $-b$, $-c$, etc., and $y=-x^2$, the roots of Equation 6 are $-a^2$, $-b^2$, $-c^2$, etc. The equation whose Encke roots are the squares of the Encke roots of Equation 1 is then

$$x^n+\begin{bmatrix}+A_1^2\\-2A_2\end{bmatrix}x^{n-1}+\begin{bmatrix}+A_2^2\\-2A_1A_3\\+2A_4\end{bmatrix}x^{n-2}+\begin{bmatrix}+A_3^2\\-2A_2A_4\\+2A_1A_5\\-2A_6\end{bmatrix}x^{n-3}$$
$$+\ldots=0\quad\ldots\ldots\ldots\ldots(7)$$

A glance at Equation 7 discloses that an equation whose roots are the squares of the roots of another equation may be formed in an orderly fashion by following this rule:

> The coefficient of any term in the new equation is formed by adding to the square of the corresponding coefficient in the original equation twice the products of the coefficients equally removed from the original coefficient, these being taken with the sign alternately (+) and (−) down the columns.

Equation 7 may be written

$$x^n+B_1\ {}^{n-1}+B_2x^{n-2}+B_3x^{n-3}+\ldots=0\quad\ldots\ldots\ldots\ldots(8)$$

where $B_1=A_1^2-2A_2$

$$B_2 = A_2^2 - 2A_1A_3 + 2A_4$$
$$B_3 = A_3^2 - 2A_2A_4 + 2A_1A_5 - 2A_6, \text{ etc.}$$

If the transformation is carried out several times, and if Equation 8 represents the last transformation, the relationships existing between the roots and coefficients of an algebraic equation can again be used. Comparing Equations 3 and 8, the following relations hold:

$$B_1 = [a^m] = a^m + b^m + c^m + \ldots.$$
$$= a^m\left(1 + \frac{b^m}{a^m} + \frac{c^m}{a^m} + \ldots\right)$$
$$B_2 = [a^m b^m] = a^m b^m + b^m c^m + a^m c^m + \ldots.$$
$$= a^m b^m\left(1 + \frac{c^m}{a^m} + \frac{c^m}{b^m} + \ldots\right), \text{etc.}$$

When the roots have been squared several times, m will be large enough to make the ratios b^m/a^m, c^m/a^m, etc., negligible because $|a| > |b| > |c|$, etc., and the ratios are small compared to unity. Then it is possible to write

$$B_1 = a^m$$
$$B_2 = a^m b^m = B_1 b^m$$
$$B_3 = a^m b^m c^m = B_2 c^m, \text{ etc.}$$

From which

$$a = B_1^{1/m} \qquad \log a = \frac{1}{m}\log B_1$$
$$b = \left(\frac{B_2}{B^1}\right)^{1/m} \qquad \log b = \frac{1}{m}(\log B_2 - \log B_1)$$
$$c = \left(\frac{B_3}{B_2}\right)^{1/m} \qquad \log c = \frac{1}{m}(\log B_3 - \log B_2)$$

These equations can be solved by logarithms as indicated, or by successive square roots, for the absolute values of the original roots of Equation 1.

The root-squaring process is repeated over and over until the doubled products no longer affect the coefficients of the next equation. The more widely separated the original roots are, the sooner this will occur. Three examples will be given to show applications of the method.

TABLE I

	Coefficient of			
m	x^3	x^2	x^1	x^0
1	1.00	—2.60	0.793	0.805
	1.00	6.74 —1.58	0.626 4.18	0.648
2	1.00	5.16	4.81	0.648
	1.00	26.7 —9.6	23.1 —6.7	0.420
4	1.00	17.1	16.4	0.420
	1.00	292 —33	268 —14	0.176
8	1.00	259	254	0.176
	1.00	67000 —500	64500 —1000	0.031
16	1.00	66500	63500	0.031

TABLE II

	Coefficient of				
m	x^4	x^3	x^2	x^1	x^0
1	1.00	—4.87	2.36	9.38	1.15
	1.00	23.7 —4.7	5.58 91.3 2.3	88.0 —5.4	1.32
2	1.00	19.0	99.2	82.6	1.32
	1.00	361 —198	9840 —3140 ...	6820 —260	1.74
4	1.00	163	6700	6560	1.74
	1.00	26600 —13400	44.9 x 10^6 —2.1 x 10^6	43.0 x 10^6	3.03
8	1.00	13200	42.8 x 10^6	43 x 10^6	3.03

EXAMPLE 1—REAL AND DISTINCT ROOTS: Equation to be solved is as follows:

$$x^3 - 2.60x^2 + 0.793x + 0.805 = 0$$

Detached coefficients are used in a tabular form, TABLE I. A 10-inch slide rule has been used for all computations.

In the table the coefficients of the original equation are written opposite $m = 1$. In the second row are the squares of the original coefficients. The third row contains minus twice the doubled products equally removed from the original coefficients. The fourth row consists of the sums of the second and third rows; these are the coefficients of the first transformed equation (Equation 7). The table is carried out until $m = 16$. For $m = 32$ the doubled products would be negligible. From the final line of the table, $B_1 = 66{,}500$, $B_2 = 63{,}500$ and $B_3 = 0.031$, therefore

$$\log a = \frac{\log 66500}{16} = 0.301 \therefore [a] = 2.00$$
$$\log b = \frac{\log 63500 - \log 66500}{16} = -.001 \therefore [b] = 1.00$$
$$\log c = \frac{\log 0.031 - \log 63500}{16} = -0.395 \therefore [c] = 0.403$$

The signs of the roots may be determined by substituting ± values of the roots in the original equation or, in this case, noting that since the sum of the roots with the sign changed is -2.60, the roots must be $+1.00$, $+2.00$, and -0.403. Frequently it is ad-

(*Continued on Page* 182)

MACHINE *Editorial* DESIGN

Broader Outlook Leads to Better Recognition

Designers have long felt that the financial recognition of their efforts is not on a par with their responsibilties. Fresh evidence to support this view is revealed in a report recently issued by the Engineers Joint Council, on the 1946 survey of the engineering profession. Based on returns received from 47,272 engineers, the report brings out a number of highly significant facts relating to the economic status of engineers.

Particularly illuminating are the figures for salaries paid to designers. For example, the median base monthly salary for designers having 25 to 29 years of experience was $417. Among engineers as a whole the corresponding figure was $511, while, as an indication of the spread in salaries, the upper 10 per cent of all engineers at this experience level received over $1000 and the lower 10 per cent less than $311.

More significant are the reported salaries for nineteen occupational groups, in twelve of which the figures are higher than for designers. Analysis reveals that, in general, engineers in the higher group are engaged in activities such as administration, management, consulting, sales, production, etc., which bring them into contact with people in many branches of business and the profession and which require a broad knowledge outside their own field. Those in salary brackets lower than the designers are to a large extent in routine jobs involving much less variety of human contacts—inspection, maintenance, testing, analysis, drafting.

The working designer has an understandable tendency to gravitate toward the more technical, specialized types of activity. Engineering principles, design calculations, and the selection of machine components and materials offer many fascinating problems—problems which can be solved by rational methods. In the other direction the problems become increasingly human problems which do not always respond to a rational approach. Management's evaluation of the ability to deal competently with these less technical but more irritating problems is accurately reflected in the figures just referred to.

Instead of lamenting the relatively poor recognition accorded them, designers would more effectively advance their status by widening their activities and striving to increase their knowledge of all aspects of manufacturing and distribution, as well as extending their acquaintanceship with men outside their own narrow circle. The prosperous designer is not the one who sits in an ivory tower but who is in the best sense a "man of the world."

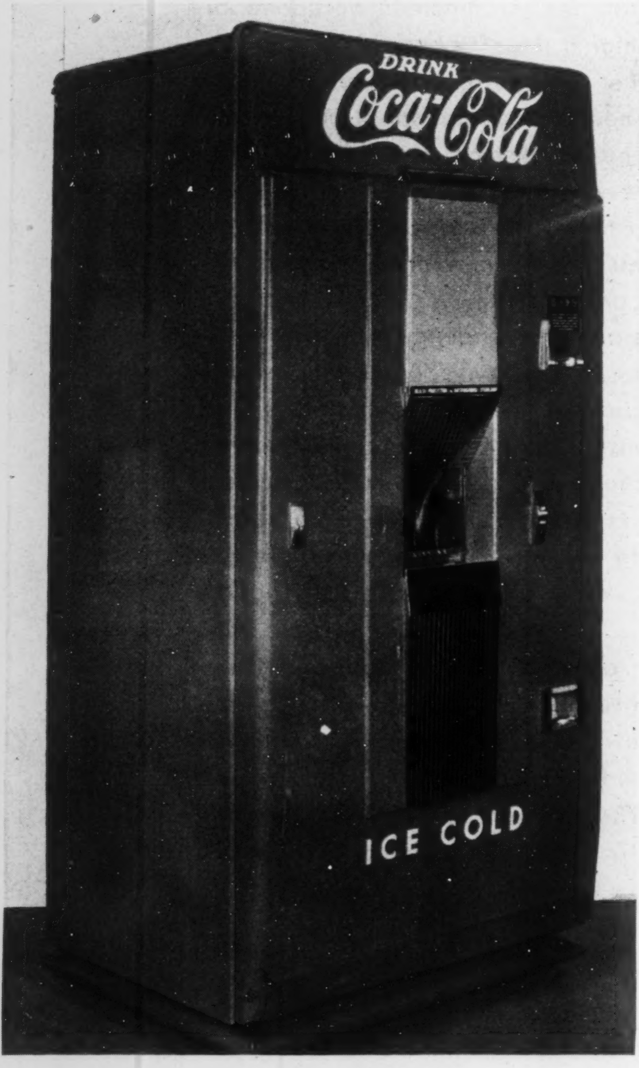
Colin Carmichael

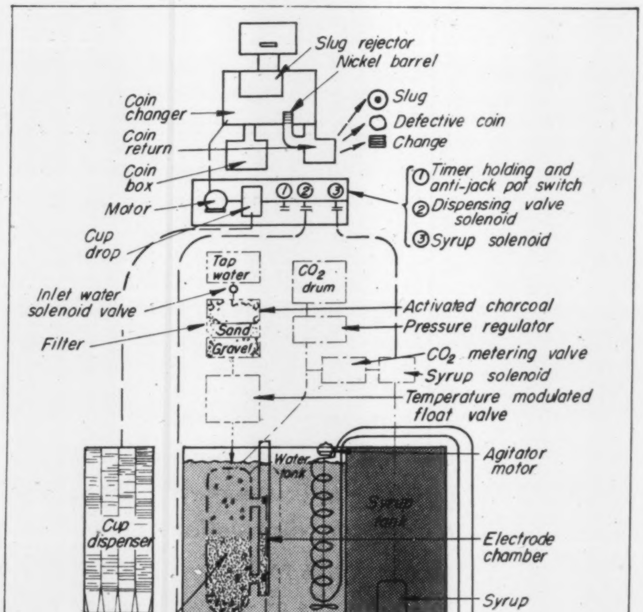
DESIGNS OF THE MONTH

Robot Drink Vendor Makes Change

COINS fed into the robot drink vendor, below, first go through a slug rejector and all which are not genuine are returned. Accepted coins actuate a switch which starts the delivery mechanism. Accepted dimes and quarters actuate a changer mechanism also, which returns a nickel for a dime or four nickels for a quarter.

As the schematic drawing, right below, shows, the machine manufactures its own carbonated water from city tap water. After passing through a filter, the water is pumped into a carbonator, where it is atomized so that it can absorb carbon dioxide and become carbonated water. The carbonator is located in the water tank, which is cooled by a hermetically-sealed condensing unit. When in operation, an agitator circulates water at the rate of 700 gallons an hour over a giant cooling coil. Machine holds 1000 cups and nine gallons of syrup. Manufacturer: Westinghouse Electric Corp., East Springfield, Mass.


DRINK
Coca-Cola
ICE COLD

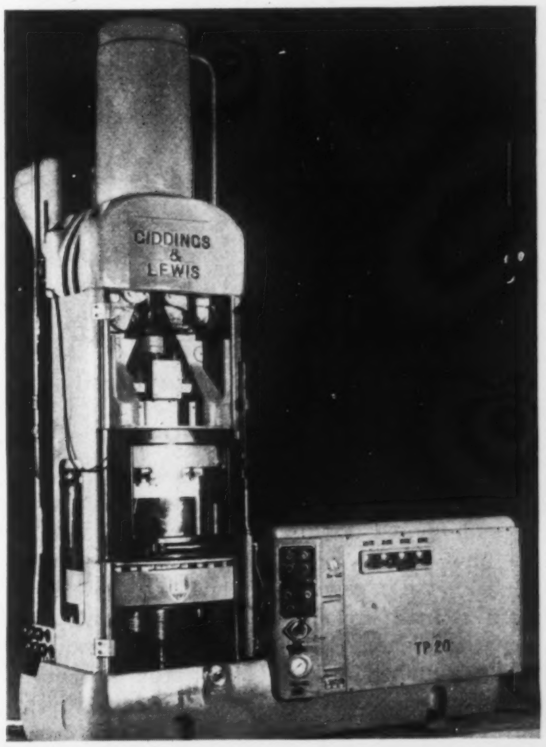

Slug rejector
Nickel barrel
Coin changer
Coin return
Coin box
Motor
Cup drop
Slug
Defective coin
Change
① Timer holding and anti-jack pot switch
② Dispensing valve solenoid
③ Syrup solenoid
Tap water
CO₂ drum
Inlet water solenoid valve
Filter
Sand
Gravel
Activated charcoal
Pressure regulator
CO₂ metering valve
Syrup solenoid
Temperature modulated float valve
Cup dispenser
Water tank
Syrup tank
Agitator motor
Electrode chamber
Syrup pump
Water pump
Carbonator
Dispensing valve solenoid
Sterilamp
Condensing unit

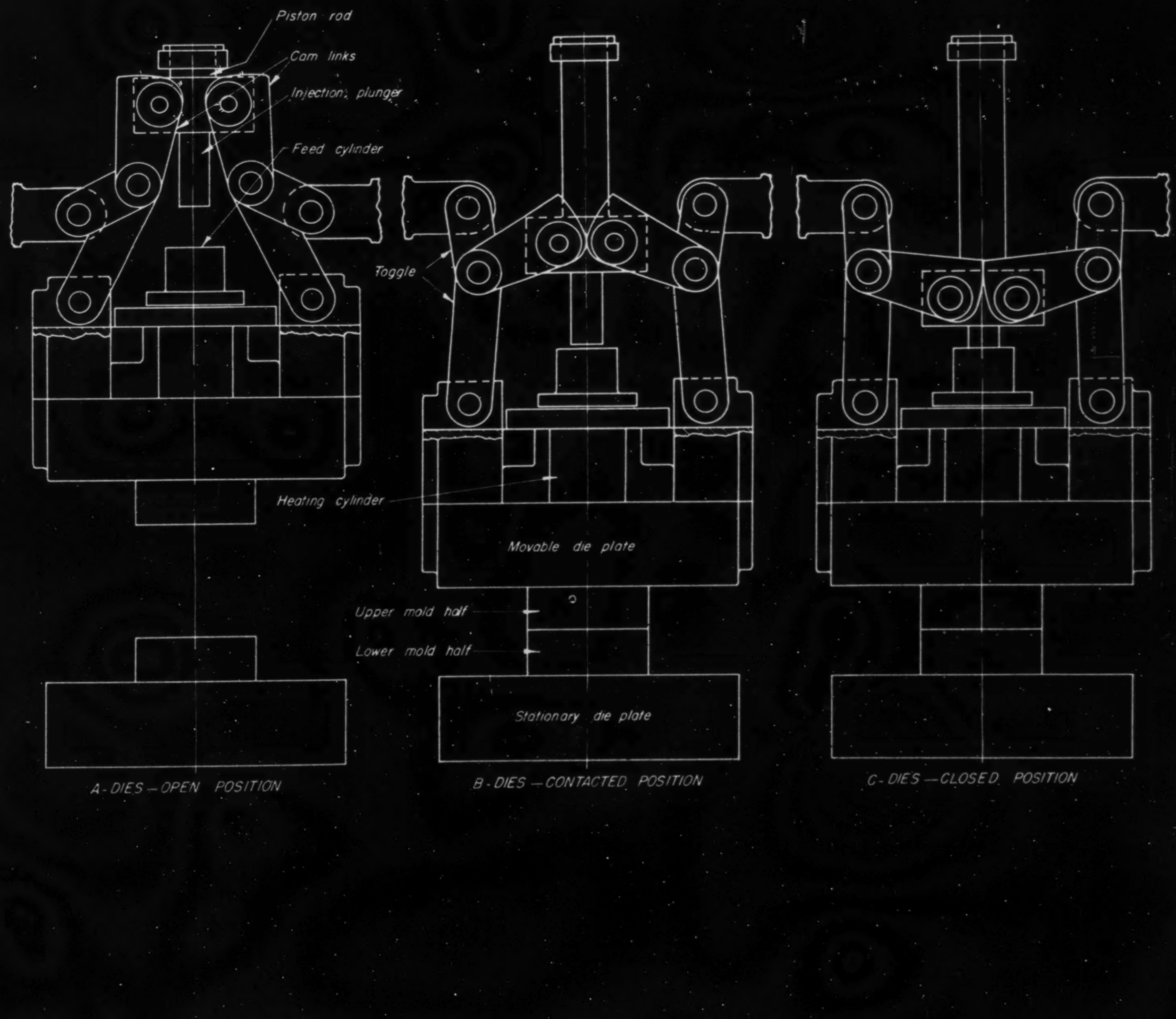
Dual-Function Piston in Plastics Press

DOWNSTROKE of a single hydraulic piston serves to clamp mold halves together and inject plastics material into mold cavity in this vertical plastics injection press. The piston is powered by a self-contained hydraulic unit which forms an integral part of the machine.

When the piston is actuated, its downward stroke operates a toggle mechanism. Starting at the "dies-open" position shown in drawing *A*, as the piston moves down, action of the toggles drives the entire upper die assembly down also until the dies are in contact (drawing *B*). From this position, further downward movement of the piston does two things simultaneously: The slight additional downward movement of the upper die assembly springs the four strain rods which connect the upper and lower sections of the press, thus creating clamping pressure on the dies, and the injection plunger forces the plastics material from the feed cylinder, through the heating cylinder and into the mold cavity. This "dies-closed" position is illustrated in drawing *C*. Magnitude of clamping pressure on the dies is controlled by adjusting the stationary die plate vertically.

All units of the press are readily accessible, removal of two covers presenting all electrical, hydraulic and mechanical devices for servicing. Control stations, including all pushbuttons and levers, are within easy reach of the operator, and centralized location makes it possible to control the machine from a sitting or standing position. Manufacturer: Giddings & Lewis Machine Tool Co., Fond du Lac, Wis.


GIDDINGS
&
LEWIS
TP 20


Piston rod
Cam links
Injection plunger
Feed cylinder
Toggle
Heating cylinder
Movable die plate
Upper mold half
Lower mold half
Stationary die plate

A-DIES—OPEN POSITION

B-DIES—CONTACTED POSITION

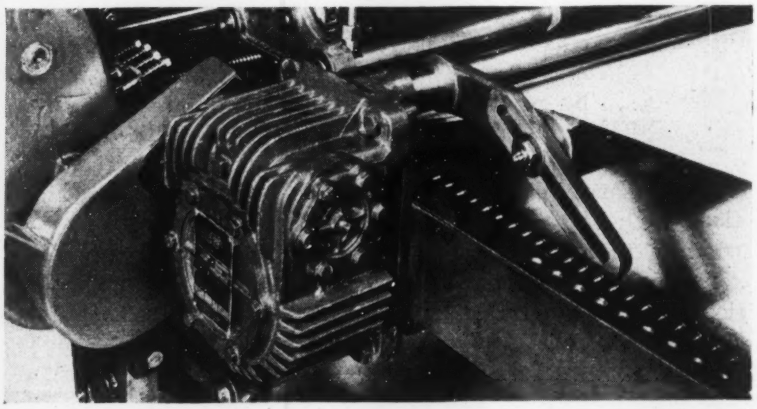
C-DIES—CLOSED POSITION

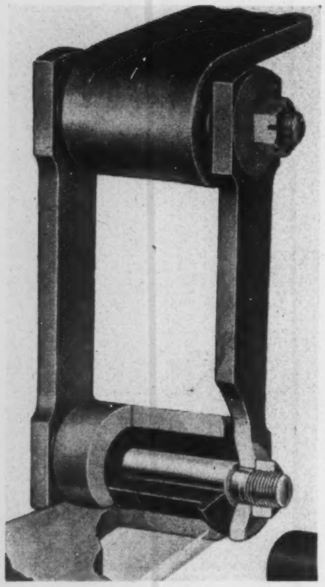
Applications

of engineering parts, materials and processes

Increases Load Capacity

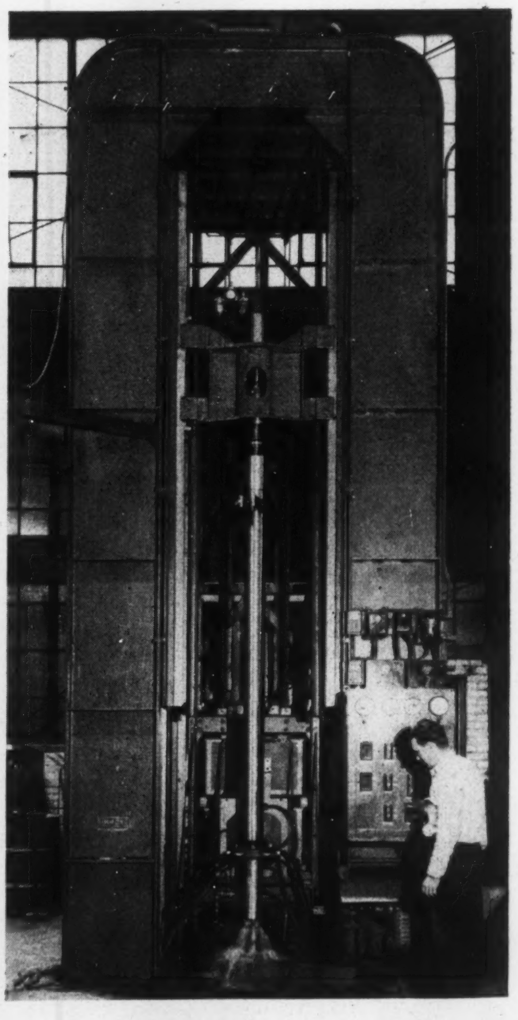
PREVIOUSLY powered by a special gear box, the discharge conveyor of the Staude paper-box making machine, right, is now driven by a Cone-Drive speed reducer. As a result cost has been lowered and a greater load-carrying capacity has been achieved. The conveyor is used to carry finished product away from the machine at a predetermined rate and thus prevent jam up. It is driven by the 50:1 reducer which in turn is driven at 300 to 900 rpm by a roller chain and sprocket.





Rubber Provides Long Life

LONG life has been attained for the new Harris spring shackle, left, through the use of a rubber bushing assembled under pressure. Load-carrying capacity and angle of turn of shackles are both dependent upon the coefficient of friction, bushing contact and pressure applied to bushing. To increase capacity without increasing size, the rubber bushing is molded with convex ends and side plates are correspondingly designed with a radius for effectively concentrating the force.



Reduces Fatigue Failure

FATIGUE-FAILURE of the Heppenstall company's steam-hammer piston rods has been greatly decreased and average life doubled by the application of induction hardening, right. High-frequency heating followed by water quenching produces a hardened case 3/16-inch deep. The effect of this case is to produce a compressive stress in the skin, aiding in counteracting tensile stresses which develop and lead to service fatigue failure. In one application where a 10-inch diameter conventional rod averaged 210 working hours in a 35,000-pound hammer, the induction-surface-hardened rod served for 598 hours.

Roll Deflection

Formulas permit calculation of deflection due to bending and shear at any point along a roll. Maximum deflection calculations are simplified by the use of a chart and by reduction to a "mill constant" which is the ratio of maximum deflection to load

By A. B. Cox
United Engineering & Foundry Co.
Pittsburgh

CALCULATION of roll deflection due to the pressure resulting from rolling plate or strip is a necessary step in determining the proper "crown", "camber", or "bulge", *Fig.* 1, to be provided on the rolls. The camber must be such that when the rolls bend due to the load the two rolls present virtually straight parallel surfaces to the plate, as shown greatly exaggerated in *Fig.* 2, resulting in a flat plate of uniform thickness.

In this data sheet are presented formulas and charts which facilitate the computation of deflections due to plate pressure, the pressure having been determined previously by calculation or test. Distortion of the rolls by temperature differences is not included in the analysis.

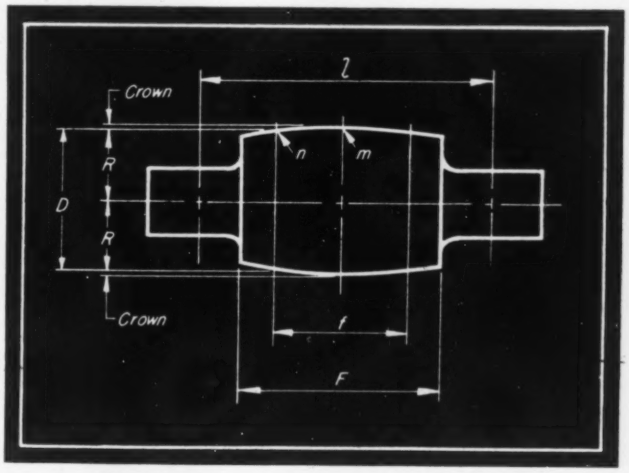


Fig. 1—Principal dimensions of cambered rolling-mill roll, showing crown greatly exaggerated

For purposes of crowning it is only necessary to know the difference between the deflections at m and at n, *Fig.* 2, that is, at the middle and edge of the plate. This simplifies the problem inasmuch as the calculations are not affected by roll-neck diameters. Although deflection due to shear may be negligible in long slender beams it cannot be neglected for short fat beams such as rolls in rolling mills. Total deflection therefore is made up of two terms, bending deflection, y_b, and shear deflection, y_s, equations for which are derived in the Appendix.

Bending deflection is given by the equation

$$y_b = \frac{5}{384}\,\frac{Wl^3}{EI}[K_b] \qquad (1)$$

Shear deflection is given by the equation

$$y_s = \frac{2Wl}{3AG}[K_s] \qquad (2)$$

The symbols in the foregoing equations are defined in the Nomenclature on the next page. Values K_b and K_s plotted in *Fig.* 3 are based on the following equations:

$$K_b = \left[\frac{1-\frac{16}{5}\left(\frac{a}{l}\right)-\frac{24}{5}\left(\frac{a}{l}\right)^2-\frac{128}{5}\left(\frac{a}{l}\right)^3-\frac{112}{5}\left(\frac{a}{l}\right)^4}{1-2\left(\frac{a}{l}\right)}\right] \qquad (3)$$

$$K_s = \left[\frac{\frac{1}{4}-\left(\frac{a}{l}\right)+\left(\frac{a}{l}\right)^2}{1-2\left(\frac{a}{l}\right)}\right] \qquad (4)$$

Deflections y_b and y_s are referred to the point n at the edge of the plate. Total deflection y_t is the sum of y_b and y_s and equals the amount of "crown" expressed as an addition to the roll radius, *Fig.* 1. Inasmuch as roll dimensions in the machine shop are measured with calipers the required figure is the addition to the diameter, or $2y_t = 2(y_b+y_s)$ on each of the two rolls. If all the crown is put on one roll the increment on the diameter is $4\ y_t$.

Inasmuch as the load W appears in both Equations 1 and 2 as a simple multiplier, the total deflection at the middle of the roll can be written

$$y_t=y_b+y_s=W\left[\frac{5}{384}\ \frac{l^3K_b}{EI}+\frac{2lK_s}{3AG}\right]=WQ \qquad (5)$$

when Q is a mill constant which does not change with change of load W as long as the width of plate, f, is the same.

If it is desired to calculate the radial crown at any point x along the roll, *Fig.* 2, this may be determined from Equations 9 and 12 in the Appendix.

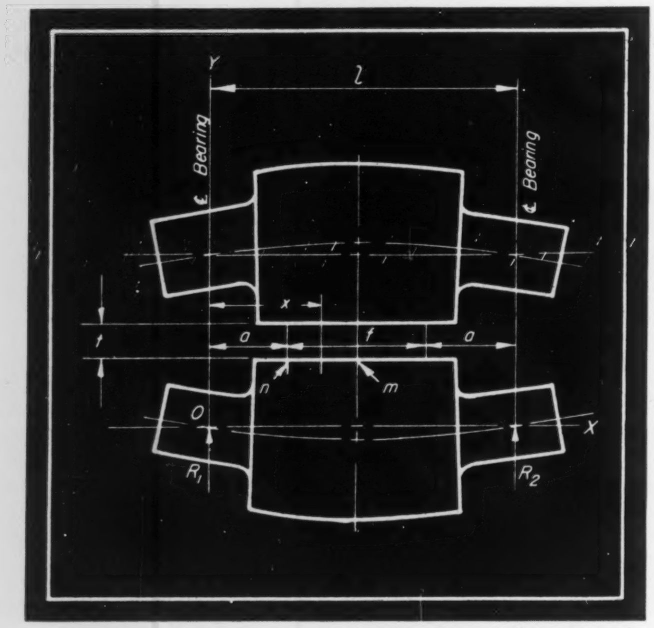


Fig. 2—Pair of cambered rolls when deflected by the load present straight parallel surfaces to the plate

Appendix—Derivation of Equations

Analysis of roll deflection need be concerned only with the difference between deflections at the center and edge of the plate. Therefore only the roll diameter has to be considered, the roll neck diameter not affecting the result[1]. The usual type of differential equation for bending can be set up and integrated between the limits $x = a$ and $x = l/2$ to obtain the maximum value of the crown. Shear deflection is calculated separately and added to the bending deflection using the principle of superposition[2].

BENDING MOMENT:[3] In determining the total load, W, the weight of the plate is always negligible and the weight of the rolls can be neglected because the weight of one roll acts to increase the deflection while the other tends to decrease it.

Nomenclature

D = Diameter of roll (in.)
l = Span between roll-neck bearings (in.)
t = Plate thickness (in.)
f = Plate width (in.)
a = Distance from edge of plate to center line of adjacent bearing (in.)
p = Pressure between plate and roll (lb per in.)
W = Total load between plate and roll (lb)
A = Area of roll cross section $=\pi D^2/4$ (in.^{2})
I = Moment of inertia of roll cross section $= \pi D^4/64$ (in.^{4})
E = Elastic modulus in tension (psi)
G = Shear modulus (psi)
K_b = Bending deflection constant, *Fig.* 3
K_s = Shear deflection constant, *Fig.* 3
Q = Mill constant
y_b = Deflection due to bending (in.)
y_s = Deflection due to shear (in)
y_t = Total deflection $= y_b + y_s$ (in.)

Referring to *Fig.* 2 and the Nomenclature, the bearing reactions are $R_1 = R_2 = pf/2$. Taking moments about any point x,

$$M=R_1x-[p(x-a)]\left(\frac{x-a}{2}\right)$$

$$M=\frac{p}{2}[-x^2+(2a+f)x-a^2]$$

But $2a + f = l$, hence

$$-M=\frac{p}{2}[x^2-lx+a^2] \qquad (6)$$

Also $W = pf$ and $f = l - 2a$, hence

$$pl=\frac{W}{1-2\left(\frac{a}{l}\right)} \qquad (7)$$

BENDING DEFLECTION:[4] The general differential

Fig. 3—Opposite Page—Constants calculated from Equations 3 and 4 for maximum deflection

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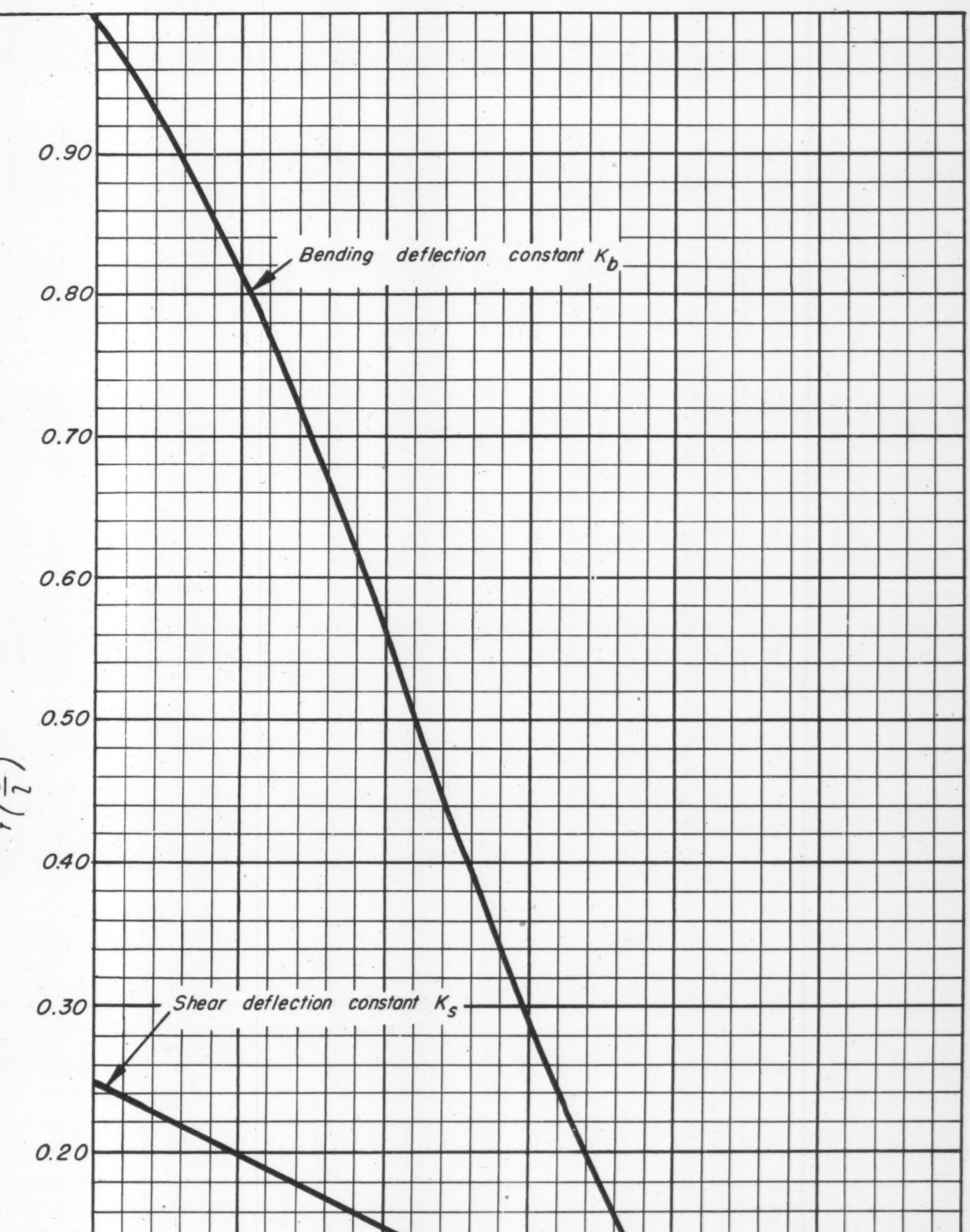
[1] References are listed at end of data sheet.


0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0
0.1
0.2
0.3
0.4
0.5
$f\left(\frac{a}{l}\right)$
$\left(\frac{a}{l}\right)$
Bending deflection constant K_b
Shear deflection constant K_s

ENGINEERING DATA SHEET

equation for simple bending is

$$\frac{d^2y}{dx^2}=\frac{-M}{EI} \qquad (8)$$

Substituting for M from Equation 6

$$\frac{d^2y}{dx^2}=\frac{p[x^2-lx+a^2]}{2EI}$$

Integrating and substituting the constant obtained by letting $dy/dx = 0$ at $x = l/2$:

$$\frac{dy}{dx}=\frac{p}{2EI}\left[\frac{x^3}{3}-\frac{lx^2}{2}+a^2x+\frac{l^3}{12}-\frac{a^2l}{2}\right]$$

Integrating again and substituting the constant obtained by letting $y = 0$ at $x = 0$

$$y=\frac{p}{2EI}\left[\frac{x^4}{12}-\frac{lx^3}{6}+\frac{a^2x^2}{2}+\frac{l^3x}{12}-\frac{a^2lx}{2}\right]$$

To find the desired difference in deflection the limits $x = x$ and $x = a$ are substituted, resulting in the following equation for deflection at any point x taking point n as zero:

$$y_b=\frac{p}{2EI}=\left[\frac{x^4}{12}-\frac{lx^3}{6}+\frac{a^2x^2}{2}+\frac{l^3x}{12}-\frac{a^2lx}{2}\right.$$
$$\left.-\frac{7a^4}{12}+\frac{2a^3l}{3}-\frac{al^3}{12}\right] \qquad (9)$$

Maximum deflection occurs at $x = l/2$, substitution of which in conjunction with Equation 7 leads to the equation

$$y_b=\frac{5}{384}\,\frac{Wl^3}{EI}\left[\frac{1-\frac{16}{5}\left(\frac{a}{l}\right)-\frac{24}{5}\left(\frac{a}{l}\right)^2+\frac{128}{5}\left(\frac{a}{l}\right)^3-\frac{112}{5}\left(\frac{a}{l}\right)^4}{1-2\left(\frac{a}{l}\right)}\right] \qquad (10)$$

which is the same as Equation 1.

SHEAR DEFLECTION:[5] The general differential equation for shear deflection is

$$\frac{d^2y}{dx^2}=-\frac{Kp}{AG} \qquad (11)$$

where K is a constant which allows for the nonuniformity of shear stress distribution over the cross section. The shear stress in a bent beam is zero at the top and bottom and a maximum at the neutral surface, following a parabolic law[6]. For the circular cross section of a roll the value of K is 4/3.

Integrating Equation 14 and substituting the constant obtained by letting $dy/dx = 0$ when $x = l/2$,

$$\frac{dy}{dx}=\frac{Kp}{AG}\left[-x+\frac{l}{2}\right]$$

Integrating again and substituting the constant corresponding to $y = 0$ when $x = 0$,

$$y=\frac{Kp}{AG}\left[\frac{-x^2}{2}+\frac{lx}{2}\right]$$

The desired difference in deflection is obtained by substituting the limits $x = x$ and $x = a$, as well as substituting $K = 4/3$, resulting in the following equation for deflection at any point x referred to point n as zero:

$$y_s=\frac{4p}{3AG}\left[\frac{-x^2}{2}+\frac{lx}{2}+\frac{a^2}{2}-\frac{al}{2}\right] \qquad (12)$$

Substituting $x = l/2$ and using Equation 7,

$$y_s=\frac{2Wl}{3AG}\left[\frac{\frac{1}{4}-\left(\frac{a}{l}\right)+\left(\frac{a}{l}\right)^2}{1-2\left(\frac{a}{l}\right)}\right] \qquad (13)$$

which is the same as Equation 2.

REFERENCES

1. S. Timoshenko—*Strength of Materials*, Vol. 1, D. Van Nostrand Co. Inc., New York, Page 212.
2. Ibid, Page 157.
3. Ibid, Page 80.
4. Ibid, Page 135.
5. Ibid, Page 170.
6. Ibid, Page 112, *Fig.* 100.

MACHINE DESIGN'S

MATERIALS WORK SHEET

FILING NUMBER
1.01

Standard Steels

Wrought AISI Types

PART II

All of the hardenability bands and their band-limit tabulations appearing on the following pages are the result of co-operative work done by joint committees of the S.A.E. and A.I.S.I.* Grades of steel covered are those on which sufficient data are available to establish reasonably authentic bands. Bands on other grades will be made available by SAE-AISI as requisite data are accumulated. All bands apply to steel in the as-quenched condition.

WHY TWO CURVES APPEAR ON GRAPHS

Just as it is impossible to produce machine parts to exact specified dimensions, so is it impossible to produce steels having exact specified amounts of the various constitutents such as carbon, nickel, manganese, chromium, etc. Tolerances on alloy constituency must be permitted. As was noted in Part I of this Work Sheet, hardenability depends on carbon content and alloy constituency. When alloy content is at the low specification limit, a steel's hardenability will be lower than when the alloy content is at the high specification limit. Thus the necessity for a high and low-limit hardenability curve for each steel.

IDENTIFYING H STEELS

When specifying a steel by hardenability, the conventional SAE-AISI number is used followed by the suffix letter "H". For example, 4142 H. It is not necessary to prefix the number with the letters SAE or AISI.

H STEEL CHEMICAL COMPOSITION

The *nominal* chemical constituency of an H steel is identical to that of a steel of the same number when specified to chemical composition. However, the *ranges* of some of the chemical constituents are broader in the H steels. For example, 1320 when specified to chemical composition has a permissible carbon range of 0.18 to 0.23 per cent. When made to meet the hardenability specification 1320 H, however the carbon range is broadened to 0.17 to 0.24 per cent. These liberalized ranges are necessary to permit production of the steels by the mills to meet hardenability specifications on a practical basis. Inasmuch as these composition modifications do not influence the properties and characteristics of the steels, neither do they affect the work of the designer.

WHICH STEEL?

Regardless of factors not predictable from hardenability, such as corrosion resistance, machinability, weldability, temperature resistance, etc., a machine part must, first and foremost, successfully withstand the loads imposed upon it in service. Thus, before the designer can select the steel for a given stressed part, he must determine what stresses to anticipate in the most critical section or sections of that part. How he determines the magnitude and location of these stresses is beyond the scope of this Work Sheet. In any case, the required yield strength in pounds per square inch in the section critically stressed is his first clue.

As an example, assume that the critically stressed section of a part is 1½ inches in diameter and requires that the minimum yield strength at any point in the section be 160,000 psi. Reference to TABLE III of Part I of this Work Sheet (MACHINE DESIGN, Sept., 1947) shows that 160,000 psi requires an as-quenched and tempered hardness of about 38 Rockwell C. Assume further that the part is intricately shaped, indicating an oil quench to reduce the danger of cracking. Referring now to the curves of *Fig. 8b* (Part I), it is seen that the cooling rate at the center of a 1½-inch round when oil quenched is about 25 degrees Fahr. per second, being equivalent to the 9/16-inch position on the Jominy bar.

The next step is to determine which of the steels will give the required hardness at the 9/16 Jominy position. An important point to bear in mind at this juncture is that the hardnesses indicated by all of the hardenability

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* Society of Automotive Engineers Iron and Steel Committee—Division 3, and the Technical Committee on Alloy Steel Bars of the American Iron and Steel Institute.

Hardenability bands and the tables "Tabulations of Hardenability Band Limits" are published in this Work Sheet through the courtesy of The Society of Automotive Engineers, Inc. and the American Iron and Steel Institute.

TABLE VI

Tabulation of Hardenability Band Limits—1300 H Series

"J" Distance (in.)	1320 H		1330 H		1335 H		1340 H	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1/16	48.0	40.5	54.0	46.5	57.0	49.5	60.0	52.5
1/8	47.5	37.0	53.5	44.5	57.0	48.0	60.0	51.5
3/16	46.5	33.0	53.0	42.0	56.5	46.0	59.5	49.5
1/4	45.0	28.5	52.0	38.0	56.0	41.5	59.0	47.0
5/16	42.5	24.0	50.5	33.5	55.0	36.0	58.5	43.0
3/8	39.0	20.5	49.0	29.5	53.5	32.0	57.5	37.0
7/16	36.0	...	47.5	27.0	51.0	29.0	56.5	32.5
1/2	33.5	...	45.0	25.0	49.0	27.0	55.0	30.0
9/16	31.5	...	43.0	23.0	47.0	25.0	53.0	28.0
5/8	30.0	...	40.0	21.5	45.0	24.0	51.5	27.0
11/16	29.0	...	38.0	21.0	43.0	23.0	49.5	25.5
3/4	28.0	...	37.0	20.0	42.0	22.0	48.0	24.5
13/16	27.5	...	36.0	...	40.5	21.0	46.0	24.0
7/8	27.0	...	35.0	...	39.5	20.5	44.5	23.0
15/16	26.5	...	34.5	...	39.0	20.0	43.0	22.5
1	26.0	...	34.0	...	38.0	...	41.5	22.0
1⅛	25.0	...	33.0	...	36.5	...	39.5	21.0
1¼	24.0	...	32.0	...	35.0	...	38.0	21.0
1⅜	23.5	...	31.5	...	34.5	...	37.0	20.5
1½	23.0	...	31.0	...	34.0	...	36.5	20.0
1⅝	22.5	...	30.0	...	33.5	...	36.0	...
1¾	22.0	...	30.0	...	33.0	...	36.0	...
1⅞	21.5	...	29.5	...	32.5	...	35.5	...
2	21.0	...	29.0	...	32.0	...	35.0	...

TABLE VII

Tabulation of Hardenability Band Limits—2500 H Series

"J" Distance (in.)	2512 H		2515 H		2517 H	
	Max.	Min.	Max.	Min.	Max.	Min.
1/16	43.0	36.5	44.5	37.5	46.0	39.0
1/8	43.0	33.5	44.5	36.0	46.0	37.5
3/16	42.0	30.0	44.0	33.0	45.5	35.0
1/4	41.0	26.5	43.0	29.0	45.0	31.0
5/16	40.0	23.0	42.0	26.0	44.0	28.0
3/8	38.5	21.0	41.0	23.0	43.0	25.5
7/16	36.5	...	39.5	21.0	42.0	23.5
1/2	35.0	...	38.0	...	40.5	21.5
9/16	33.5	...	36.0	...	38.5	20.0
5/8	32.0	...	34.5	...	37.0	...
11/16	30.5	...	33.0	...	35.5	...
3/4	29.5	...	32.0	...	34.5	...
13/16	28.0	...	30.5	...	33.0	...
7/8	27.0	...	29.5	...	32.5	...
15/16	26.5	...	28.5	...	31.5	...
1	25.5	...	28.0	...	31.0	...
1⅛	24.0	...	26.5	...	29.5	...
1¼	23.0	...	26.0	...	28.5	...
1⅜	22.0	...	25.0	...	27.5	...
1½	21.5	...	24.0	...	27.0	...
1⅝	21.0	...	23.5	...	26.0	...
1¾	20.5	...	23.0	...	26.0	...
1⅞	20.0	...	23.0	...	25.5	...
2	20.0	...	23.0	...	25.0	...

TABLE VIII

Tabulation of Hardenability Band Limits—3100 H Series

"J" Distance (in.)	3140 H	
	Max.	Min.
1/16	60.0	52.5
1/8	59.5	51.5
3/16	59.0	50.0
1/4	58.5	49.0
5/16	58.0	47.5
3/8	57.5	45.5
7/16	56.5	43.5
1/2	56.0	41.0
9/16	55.0	38.5
5/8	54.0	36.5
11/16	53.0	34.5
3/4	52.0	33.5
13/16	51.0	32.0
7/8	50.0	31.5
15/16	48.5	30.5
1	47.5	30.0
1⅛	46.0	29.0
1¼	44.5	28.5
1⅜	43.0	28.0
1½	42.0	27.5
1⅝	41.0	27.0
1¾	40.5	26.5
1⅞	40.0	26.0
2	39.0	25.0

TABLE IX

Tabulation of Hardenability Band Limits—3300 H Series

"J" Distance (in.)	3310 H		3316 H	
	Max.	Min.	Max.	Min.
1/16	42.5	35.5	47.5	40.0
1/8	42.0	35.0	47.0	39.0
3/16	41.5	34.0	47.0	38.0
1/4	41.0	33.0	46.0	37.0
5/16	41.0	31.0	45.5	35.5
3/8	40.5	30.0	45.0	34.5
7/16	40.0	29.0	44.5	33.5
1/2	39.5	28.0	44.0	32.5
9/16	39.5	27.5	43.5	32.0
5/8	39.0	27.0	43.0	31.5
11/16	38.5	26.5	43.0	31.0
3/4	38.0	26.0	42.5	30.5
13/16	37.5	25.5	42.0	30.0
7/8	37.5	25.5	41.5	30.0
15/16	37.0	25.0	41.0	29.5
1	36.5	25.0	40.5	29.5
1⅛	35.5	24.5	40.0	29.0
1¼	35.0	24.5	39.5	28.5
1⅜	34.5	24.0	39.0	28.5
1½	34.0	24.0	39.0	28.5
1⅝	34.0	24.0	39.0	28.5
1¾	34.0	24.0	39.0	28.5
1⅞	34.0	24.0	38.5	28.5
2	34.0	24.0	38.5	28.5

TABLE X—Tabulation of Hardenability Band Limits—4100 H Series

"J" Distance (in.)	4130 H		4132 H		4135 H		4137 H		4140 H		4142 H		4145 H		4147 H		4150 H	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1/16	54.0	46.5	55.5	48.0	57.0	50.0	58.5	51.5	60.0	52.5	62.0	54.0	63.0	55.0	64.0	56.5	65.0	58.0
1/8	54.0	45.0	55.0	46.0	57.0	49.0	58.5	50.5	60.0	52.0	62.0	53.5	63.0	54.5	64.0	56.5	65.0	58.0
3/16	53.0	42.0	54.5	43.5	57.0	48.0	58.5	49.0	60.0	51.0	61.5	53.0	62.5	54.0	63.5	56.0	65.0	57.5
1/4	52.0	39.0	53.5	40.5	56.5	46.0	58.0	47.5	59.5	50.0	61.0	52.0	62.0	53.0	63.5	55.0	65.0	57.0
5/16	50.5	36.0	52.0	37.5	55.5	44.5	57.5	46.0	59.0	48.5	61.0	51.0	62.0	52.5	63.0	54.5	64.5	56.5
3/8	48.0	33.5	50.5	35.5	54.5	42.0	57.0	44.0	59.0	47.0	60.5	49.0	61.5	51.0	63.0	53.5	64.5	55.0
7/16	45.0	31.5	48.5	33.5	53.5	39.5	56.0	42.0	58.5	45.0	60.5	47.5	61.0	50.0	62.5	52.0	64.0	54.0
1/2	43.0	30.0	46.5	32.0	52.0	37.5	55.0	40.0	58.0	43.5	60.0	45.5	61.0	48.5	62.0	50.5	64.0	53.0
9/16	41.5	28.5	44.5	31.0	51.0	35.5	54.0	38.0	58.0	41.5	59.5	43.5	60.5	47.0	62.0	49.0	64.0	51.5
5/8	40.0	27.5	43.0	29.5	49.5	34.0	53.0	36.5	57.5	40.0	59.0	42.0	60.0	45.0	61.5	47.5	63.5	50.0
11/16	38.5	26.5	42.0	29.0	48.5	32.0	52.0	34.5	57.0	38.5	58.5	40.5	60.0	43.5	61.5	45.5	63.0	48.0
3/4	37.5	26.0	40.5	28.0	47.5	31.0	51.0	33.5	56.0	37.5	58.0	39.5	59.5	42.0	61.0	44.5	63.0	46.5
13/16	36.0	25.0	39.5	27.0	46.5	30.5	50.0	32.5	55.5	36.5	57.5	38.5	59.0	40.5	61.0	43.0	63.0	45.0
7/8	35.0	24.0	39.0	26.5	45.5	29.5	49.5	32.0	55.0	35.5	57.0	37.5	59.0	39.5	60.5	42.0	62.5	44.0
15/16	34.5	23.5	38.0	26.0	45.0	29.0	48.5	31.0	54.5	34.5	56.5	37.0	58.5	38.5	60.5	40.5	62.0	42.5
1	33.5	23.0	37.5	25.0	44.0	28.5	48.0	30.5	54.0	34.0	56.0	36.0	58.0	38.0	60.0	40.0	62.0	42.0
1⅛	32.5	22.0	36.0	24.0	43.0	28.0	47.0	30.0	53.0	33.0	55.5	35.0	57.5	36.5	60.0	38.0	61.5	40.0
1¼	31.5	21.0	35.5	23.0	42.0	27.5	46.5	29.0	52.0	32.0	54.5	34.0	57.0	35.5	59.0	37.0	61.0	39.0
1⅜	31.0	20.5	35.0	22.5	41.5	27.0	45.5	29.0	51.5	31.5	54.0	33.0	56.0	34.5	58.5	36.0	60.5	38.0
1½	30.5	20.0	34.0	22.0	41.0	26.5	45.0	28.5	51.0	31.0	53.0	32.5	55.5	34.0	58.0	35.5	60.0	37.0
1⅝	30.0	...	34.0	21.0	40.5	26.0	45.0	28.0	50.5	30.0	52.5	32.0	55.0	33.5	57.5	35.0	59.5	36.5
1¾	30.0	...	34.0	20.5	40.0	26.0	44.5	27.5	50.0	30.0	52.5	31.5	54.5	33.0	57.0	34.5	59.0	36.0
1⅞	29.5	...	34.0	20.5	40.0	25.5	44.0	27.5	49.5	29.5	52.0	31.0	54.0	33.0	56.0	34.0	58.5	36.0
2	29.5	...	34.0	20.0	39.5	25.5	44.0	27.0	49.0	29.5	51.5	30.5	53.5	32.5	55.5	34.0	58.0	35.5

curves are for the steels *as quenched*. Since the requisite hardness in this example (Rockwell C 38) at the 9/16 Jominy position is for steel *as quenched and tempered*, some degree of hardness will have to be added to the Rockwell C 38 value to allow for the softening which will occur during tempering. In general, five to ten points Rockwell C should be adequate. Thus, in this case, eight points are added, giving a required as-quenched hardness at the 9/16 "J" position of 46 Rockwell C.

This value of 46 Rockwell C is the minimum hardness required. Inasmuch—as has been indicated—a tolerance must be allowed on hardenability, a maximum permissible value must also be assigned for the 9/16 Jominy position. Reference to TABLES VI through XIX will show that at the 9/16 "J" distance, any one of the following steels will meet the minimum requirement:

Steel Number	Hardness at 9/16 "J" Distance (Rockwell C)	
	Max.	Min.
4145 H	60.5	47
4147 H	62	49
4150 H	64	51.5
4340 H	60	52
8650 H	61	46.5
8655 H	65	50.5
8660 H	65+	54
8747 H	61	46
8750 H	64	49

On the basis of this tabulation the most logical choices would appear to 8747 H, 8650 H, and 4145 H. However, it will be recalled from *Fig*. 6 (Part I) that, depending on its carbon content, a steel must quench to a certain minimum hardness if it is to have reasonably predictable properties after tempering. Thus, the next step is to determine which of the listed steels have a minimum hardness at the 9/16 "J" distance equal to or greater than that indicated in *Fig*. 6 when their carbon contents are at the low side of the permissible ranges shown in TABLE XX. A listing such as the following facilitates this check:

Steel Number	Min. Carbon Content (Table XX)	Min. Hardness Permissible (Fig. 6)	Min. Hardness at 9/16 "J" Distance
4145 H	0.42	50 R C	47 R C
4147 H	0.44	51 R C	49 R C
4150 H	0.46	52 R C	51.5 R C
4340 H	0.37	48 R C	52 R C
8650 H	0.46	52 R C	46.5 R C
8655 H	0.50	52.5 R C	50.5 R C
8660 H	0.55	54 R C	54 R C
8747 H	0.44	51 R C	46 R C
8750 H	0.46	52 R C	49 R C

Since the minimum as-quenched hardness values recommended in *Fig*. 6 are equalled or exceeded only by steels 4150 H (barely), 4340 H and 8660 H, final choice narrows down to one of these three. Inasmuch as cost of steels generally rises with increasing hardenability, and inasmuch as the as-quenched hardness required in this example is 46 Rockwell C, the most logical choice would be 4150 H. Of course this choice has been made strictly on the basis of hardenability. Other factors pertinent to the application, such as design, availability, cost, machinability, forgeability, processing facilities, etc,, might make another steel the more logical choice.

It should be emphasized that while the procedure described in the immediate foregoing is a great deal more realistic and practicable than selection based on pure guess work or on values blandly picked from tabular listings of properties, there is no substitute for competent metallurgical advice in cases where parts are critical and are to be mass produced. It is suggested also, that where feasible, the designer should check his selections based on the foregoing procedure with a metallurgist.

SPECIFYING BY HARDENABILITY

When designating a steel by hardenability on a part drawing, the full lengths of the hardenability curves should not be specified. Instead, two specific points on the hardenability band curves should be selected which suit the requirements of the application. Since the designer's primary concern is with the hardness at a critical section of a part, it is necessary to specify only those points on the curves which will insure the requisite hardness at that critical section.

Furthermore, the curves of individual heats of steel will vary considerably in shape within the confines of the minimum and maximum curves which form the standard hardenability bands and, since there is no way to predict what shape the curve of any heat will be, specification by full-length curve is not practicable.

Any one of the following five two-point methods recommended by AISI may be employed—depending on part re-

TABLE XI

Tabulation of Hardenability Band Limits—4300 Series

"J" Distance (in.)	Grade					
	4317 H		4320 H		4340 H	
	Max.	Min.	Max.	Min.	Max.	Min.
1/16	47.0	40.0	49.0	41.5	60.0	52.5
1/8	46.0	35.5	48.0	38.5	60.0	52.5
3/16	44.5	31.5	46.5	34.0	60.0	52.5
1/4	42.5	28.5	44.5	31.0	60.0	52.5
5/16	40.5	26.0	42.0	29.0	60.0	52.5
3/8	37.5	24.0	40.0	27.0	60.0	52.5
7/16	35.0	22.5	37.5	25.0	60.0	52.5
1/2	33.0	21.0	35.5	24.0	60.0	52.0
9/16	31.5	20.0	34.0	22.5	60.0	52.0
5/8	30.0	...	32.5	21.5	60.0	51.5
11/16	29.0	...	31.0	20.5	60.0	51.5
3/4	28.0	...	30.0	20.0	60.0	51.0
13/16	27.0	...	29.5	...	60.0	51.0
7/8	26.5	...	29.0	...	60.0	50.5
15/16	26.0	...	28.0	...	60.0	50.5
1	25.5	...	27.5	...	60.0	50.0
1⅛	24.5	...	27.0	...	60.0	49.0
1¼	24.0	...	26.5	...	60.0	48.0
1⅜	23.5	...	26.0	...	60.0	47.0
1½	23.0	...	26.0	...	60.0	46.0
1⅝	23.0	...	25.5	...	60.0	45.0
1¾	23.0	...	25.5	...	60.0	44.5
1⅞	23.0	...	25.5	...	60.0	44.0
2	23.0	...	25.5	...	60.0	43.0

TABLE XII

Tabulation of Hardenability Band Limits—4600 H Series

"J" Distance (in.)	Grade			
	4620 H		4640 H	
	Max.	Min.	Max.	Min.
1/16	48.0	40.5	60.0	52.5
1/8	45.5	31.0	60.0	51.5
3/16	43.0	26.0	59.5	50.5
1/4	39.0	22.0	59.0	49.0
5/16	35.5	20.0	57.5	46.0
3/8	33.0	...	56.5	43.0
7/16	31.0	...	55.0	40.0
1/2	29.5	...	53.0	37.5
9/16	28.0	...	50.5	35.0
5/8	27.5	...	49.0	33.5
11/16	26.5	...	47.5	32.0
3/4	26.0	...	46.0	31.0
13/16	25.5	...	45.0	29.5
7/8	25.0	...	44.0	29.0
15/16	24.5	...	43.5	28.0
1	24.0	...	42.5	27.5
1⅛	23.5	...	41.5	26.5
1¼	23.0	...	41.0	25.5
1⅜	22.5	...	40.0	25.0
1½	22.5	...	39.5	25.0
1⅝	22.0	...	39.0	24.5
1¾	22.0	...	38.5	24.0
1⅞	22.0	...	38.0	24.0
2	22.0	...	38.0	24.0

quirements—to specify a steel on the basis of hardenability:

1. Designation of the minimum and maximum distances at which desired hardness occurs (points A-A of *Fig.* 10)
2. Designation of the minimum and maximum hardness values at any desired distance (points B-B of *Fig.* 10)
3. Designation of two maximum hardness values at two desired distances (points C-C of *Fig.* 10)
4. Designation of two minimum hardness values at two desired distances (points D-D of *Fig.* 10)
5. Designation of any point on minimum curve plus any point on maximum curve (not illustrated)

Where it is considered desirable, the maximum and minimum hardness limits at the 1/16-in. "J" distance may be specified in addition to the other two points.

This leads to the actual writing down of the steel

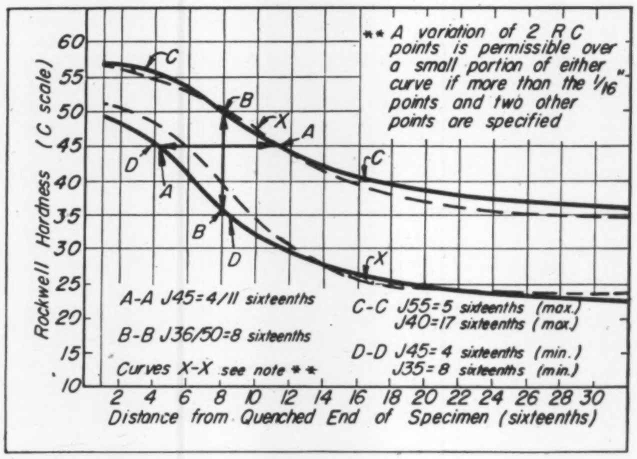


Fig. 10—In specifying "H" steels, any one of the two-point methods indicated above is acceptable

TABLE XIII

Tabulation of Hardenability Band Limits—4800 H Series

"J" Distance	Grade							
	4812 H		4815 H		4817 H		4820 H	
(in.)	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1/16	43.5	37.0	45.0	38.0	46.0	39.0	48.0	40.5
1/8	43.0	33.0	44.5	37.0	45.5	38.0	47.5	39.5
3/16	42.0	29.5	44.0	34.0	45.0	35.5	47.0	37.5
1/4	41.0	26.5	43.0	30.0	44.0	32.0	46.0	35.0
5/16	39.5	24.5	41.5	27.0	43.0	29.0	45.0	32.0
3/8	38.0	22.5	40.0	25.5	42.0	27.0	43.5	30.0
7/16	37.0	21.0	38.5	24.0	40.5	25.0	42.5	28.0
1/2	35.0	20.0	37.5	22.5	39.0	23.5	41.0	26.5
9/16	33.5	...	36.0	21.0	37.5	22.5	39.0	25.5
5/8	32.0	...	34.5	20.5	35.5	21.5	37.5	24.5
11/16	30.5	...	33.0	20.0	34.0	20.5	36.0	23.5
3/4	29.0	...	31.0	...	32.5	20.0	34.5	23.0
13/16	28.0	...	30.0	...	31.0	...	33.5	22.0
7/8	27.0	...	29.0	...	30.0	...	32.5	21.5
15/16	26.0	...	28.5	...	29.5	...	31.5	21.0
1	25.5	...	28.0	...	29.0	...	31.0	20.5
1⅛	24.5	...	27.0	...	28.0	...	30.0	20.0
1¼	24.0	...	26.5	...	27.0	...	29.0	...
1⅜	23.5	...	25.5	...	26.5	...	28.5	...
1½	23.0	...	25.5	...	26.0	...	28.0	...
1⅝	23.0	...	25.0	...	25.5	...	27.5	...
1¾	22.5	...	25.0	...	25.5	...	27.0	...
1⅞	22.5	...	24.5	...	25.0	...	27.0	...
2	22.5	...	24.0	...	25.0	...	26.5	...

TABLE XIV

Tabulation of Hardenability Band Limits—5100 H Series

"J" Distance	Grade					
	5140 H		5145 H		5150 H	
(in.)	Max.	Min.	Max.	Min.	Max.	Min.
1/16	60.0	52.5	63.0	55.0	65.0	58.0
1/8	59.5	52.0	62.5	54.5	65.0	57.5
3/16	59.0	50.0	62.0	53.0	64.5	56.5
1/4	58.0	47.0	61.0	51.0	64.0	55.0
5/16	57.0	42.0	60.0	48.0	63.5	52.0
3/8	55.0	37.0	58.5	42.0	62.5	48.0
7/16	53.0	33.5	57.0	36.5	61.5	43.0
1/2	51.0	31.5	55.5	33.5	60.0	37.5
9/16	49.0	29.5	53.5	31.5	58.5	33.5
5/8	47.0	28.0	52.0	30.0	57.0	32.0
11/16	45.0	27.0	50.0	29.0	55.0	31.0
3/4	43.5	26.0	48.0	28.0	52.0	30.0
13/16	42.0	25.5	46.0	27.5	50.0	29.5
7/8	41.0	25.0	44.5	27.0	48.0	29.0
15/16	40.0	24.5	43.0	26.5	46.5	28.5
1	39.0	24.0	42.0	26.0	45.0	28.0
1⅛	37.5	23.0	40.5	25.0	43.5	27.0
1¼	36.0	22.0	39.0	24.0	42.0	26.0
1⅜	35.0	21.0	38.0	23.0	41.0	25.0
1½	34.0	20.0	37.0	22.0	40.0	24.0
1⅝	33.0	...	36.0	21.0	39.0	23.0
1¾	32.0	...	35.0	20.0	38.0	22.0
1⅞	31.0	...	34.0	...	37.0	21.0
2	30.0	...	33.0	...	36.0	20.0

TABLE XV

Tabulation of Hardenability Band Limits—6100 H Series

"J" Distance	Grade	
	6150 H	
(in.)	Max.	Min.
1/16	65.0	58.0
1/8	64.5	57.5
3/16	64.0	57.0
1/4	63.5	56.0
5/16	62.5	54.0
3/8	62.0	51.0
7/16	61.0	48.5
1/2	60.0	45.5
9/16	59.0	42.5
5/8	58.0	40.0
11/16	57.0	38.0
3/4	56.0	36.5
13/16	55.0	35.5
7/8	53.5	35.0
15/16	52.0	34.5
1	51.0	34.0
1⅛	48.0	33.0
1¼	46.0	31.5
1⅜	45.0	30.5
1½	44.0	29.5
1⅝	43.0	28.5
1¾	42.0	27.5
1⅞	41.0	26.5
2	40.0	25.0

TABLE XVI

Tabulation of Hardenability Band Limits—8600 H Series 8617 to 8635

"J" Distance	Grade															
	8617 H		8620 H 1st Rev.		8622 H		8625 H		8627 H		8630 H 1947		8632 H		8635 H	
(in.)	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min
1/16	46.0	39.0	48.0	40.5	49.5	42.0	50.5	43.5	52.5	45.5	54.0	46.5	55.5	48.0	57.0	49.5
1/8	44.5	29.5	46.5	35.0	48.0	35.5	50.0	38.5	52.0	42.0	54.0	45.0	55.5	47.0	57.0	48.5
3/16	42.0	25.0	44.0	30.0	46.5	30.0	48.5	34.0	50.0	37.5	53.0	42.5	55.0	45.0	57.0	47.0
1/4	39.0	22.0	41.0	26.0	43.5	27.5	46.5	31.0	49.0	35.0	51.5	39.5	54.0	42.0	56.0	44.5
5/16	35.0	20.0	37.0	23.5	40.5	25.0	44.0	28.5	47.0	32.0	50.0	35.0	52.5	38.5	55.0	42.0
3/8	32.5	...	34.5	21.0	38.0	23.5	41.0	26.5	44.5	30.0	47.0	31.5	50.5	35.5	53.0	38.0
7/16	30.5	...	32.5	...	35.5	22.0	38.5	25.0	42.0	28.0	44.0	29.5	48.0	33.0	51.0	35.5
1/2	29.0	...	31.0	...	34.0	21.0	37.0	23.5	40.0	26.5	41.0	28.0	45.5	31.0	48.0	33.5
9/16	28.0	...	29.5	...	32.0	20.0	35.0	22.5	38.0	25.0	38.5	27.0	43.5	29.0	46.0	31.5
5/8	27.0	...	28.5	...	31.0	...	34.0	21.5	36.5	24.0	37.0	25.5	42.0	28.0	44.5	30.0
11/16	26.0	...	28.0	...	30.0	...	32.5	20.0	35.0	23.0	35.0	25.0	40.5	27.0	43.0	28.5
3/4	25.0	...	27.0	...	29.0	...	32.0	...	34.0	22.0	34.0	24.0	39.0	26.0	42.0	27.5
13/16	24.5	...	26.0	...	28.5	...	31.0	...	33.0	21.5	33.0	23.0	38.0	25.0	40.5	26.5
7/8	24.0	...	25.5	...	28.0	...	30.0	...	32.5	21.0	32.5	22.5	37.0	24.5	39.5	26.0
15/16	23.5	...	25.0	...	27.5	...	29.5	...	31.5	20.0	32.0	22.0	36.5	23.5	39.0	25.0
1	23.0	...	24.5	...	27.0	...	29.0	...	31.0	...	31.5	21.5	35.5	23.0	38.0	24.5
1⅛	22.0	...	24.0	...	26.0	...	28.0	...	30.0	...	30.5	21.0	34.5	22.0	37.0	24.0
1¼	21.5	...	23.0	...	25.5	...	27.0	...	29.0	...	30.0	20.5	33.5	21.5	36.0	23.0
1⅜	21.0	...	23.0	...	25.0	...	26.5	...	28.0	...	29.5	20.0	33.0	21.0	35.0	22.5
1½	20.5	...	22.5	...	24.5	...	26.0	...	28.0	...	29.0	...	32.5	20.5	34.5	22.0
1⅝	20.5	...	22.0	...	24.0	...	26.0	...	27.5	...	29.0	...	32.0	20.0	34.0	21.5
1¾	20.0	...	22.0	...	24.0	...	26.0	...	27.5	...	29.0	...	32.0	20.0	33.5	21.5
1⅞	20.0	...	22.0	...	24.0	...	20.6	...	27.5	...	29.0	...	31.5	...	33.0	21.0
2	20.0	...	22.0	...	24.0	...	26.0	...	27.5	...	29.0	...	31.5	....	33.0	21.0

specification on a drawing. Using alloy steel 4640 H as an example, the manner of specifying, using each of the five two-point methods listed in the foregoing is as follows (see hardenability band for 4640 H):

1. Alloy steel 4640 H,
   J45 = 5/13 sixteenths
2. Alloy steel 4640 H,
   J37.5/53 at 8 sixteenths
3. Alloy steel 4640 H,
   J57 max. at 5 sixteenths
   J42 max. at 17 sixteenths
4. Alloy steel 4640 H,
   J49 min. at 4 sixteenths
   J37 min. at 8 sixteenths
5. Alloy steel 4640 H,
   J33 min. at 10 sixteenths
   J58 max. at 4 sixteenths

The latest SAE-AISI tentative hardenability bands appear on the following eight pages.

TABLE XVII—**Tabulation of Hardenability Band Limits—8600 H Series (8637 to 8660)**

"J" Distance	Grade															
	8637 H		8640 H 8641 H 1947		8642 H		8645 H 1947		8647 H		8650 H		8655 H		8660 H	
(in.)	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1/16	58.5	51.5	60.0	52.5	62.0	54.0	63.0	55.0	64.0	56.5	65.0	58.0	...	60.0	...	60.0
1/8	58.5	50.5	60.0	52.5	62.0	53.0	63.0	55.0	64.0	56.0	65.0	57.5	...	59.5	...	60.0
3/16	58.0	49.0	60.0	52.0	62.0	52.0	63.0	55.0	64.0	55.0	65.0	56.5	...	59.0	...	60.0
1/4	57.5	47.0	59.5	51.0	61.0	50.5	62.5	54.0	64.0	53.5	65.0	55.0	...	58.0	...	59.5
5/16	56.0	44.0	58.5	49.0	60.0	48.0	62.0	52.5	63.5	52.0	64.5	53.5	...	57.0	...	59.0
3/8	55.0	40.5	58.0	46.0	59.0	45.5	61.5	50.5	62.5	50.0	63.5	52.0	...	55.5	...	58.0
7/16	53.0	37.5	56.5	42.0	57.5	42.5	60.5	48.0	61.5	48.0	63.0	50.0	...	54.0	...	57.0
1/2	50.5	35.5	55.0	39.0	56.0	40.5	59.5	45.0	60.5	45.5	62.0	48.5	...	52.0	...	55.5
9/16	49.0	33.5	53.5	36.5	54.0	38.0	58.5	41.5	59.0	43.5	61.0	46.5	65.0	50.5	...	54.0
5/8	47.0	32.0	52.0	34.0	52.5	36.5	57.5	39.0	57.5	41.5	60.0	44.5	64.5	48.5	...	52.0
11/16	45.5	30.5	50.5	32.5	51.0	35.0	56.0	37.0	56.5	40.0	59.0	42.5	64.0	47.0	...	50.0
3/4	44.0	29.5	48.5	31.0	50.0	33.5	55.0	35.5	55.0	38.5	58.0	41.0	63.0	45.0	...	48.5
13/16	43.0	28.5	46.5	30.0	48.5	32.0	54.0	34.0	54.0	37.0	57.0	39.5	62.0	43.5	...	47.0
7/8	42.0	28.0	45.0	29.0	47.5	31.0	52.0	33.0	53.0	35.5	56.0	38.0	61.0	42.0	65.0	45.5
15/16	41.0	27.0	43.5	28.0	46.5	30.0	50.5	32.0	52.0	34.5	55.0	37.0	60.0	40.5	64.5	44.5
1	40.0	26.5	42.5	27.5	46.0	29.5	49.0	31.0	51.0	33.5	54.0	36.0	59.0	39.5	64.0	43.0
1⅛	39.0	25.0	40.5	26.5	44.5	28.5	46.5	30.0	49.5	32.0	52.0	34.0	57.0	37.5	62.0	41.0
1¼	38.0	24.5	39.5	26.0	43.0	27.5	45.0	29.0	48.0	31.0	51.0	32.5	55.5	36.0	60.0	39.0
1⅜	37.0	24.0	38.5	25.0	42.0	27.0	43.5	28.5	47.0	30.0	49.5	31.5	54.0	35.0	58.5	38.0
1½	36.5	23.5	37.5	25.0	41.5	26.0	42.5	28.0	46.0	29.0	48.5	31.0	53.0	34.0	57.5	37.0
1⅝	36.0	23.0	37.5	24.5	40.5	26.0	41.5	27.5	45.5	29.0	48.0	30.5	52.0	33.0	56.5	35.5
1¾	35.5	22.5	37.0	24.5	40.0	25.5	41.5	27.5	45.0	28.5	47.0	30.0	51.5	32.5	56.0	35.0
1⅞	35.5	22.5	37.0	24.0	39.5	25.5	41.0	27.0	44.0	28.0	46.5	29.5	51.0	32.0	55.5	34.0
2	35.0	22.5	37.0	24.0	39.0	25.5	41.0	27.0	43.5	28.0	46.0	29.5	50.5	31.5	55.0	33.5

TABLE XVIII—**Tabulation of Hardenability Band Limits—8700 H Series**

"J" Distance	Grade													
	8720 H		8735 H		8740 H		8742 H		8745 H		8747 H		8750 H	
(in.)	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1/16	48.0	40.5	57.0	49.5	60.0	52.5	62.0	54.0	63.0	55.0	64.0	56.5	65.0	58.0
1/8	46.5	35.5	57.0	48.5	60.0	52.0	62.0	53.5	63.0	55.0	64.0	56.0	65.0	58.0
3/16	44.5	29.0	56.5	47.5	60.0	51.0	61.5	53.0	63.0	54.5	64.0	55.5	65.0	57.5
1/4	41.5	25.5	56.0	45.5	59.0	49.5	61.0	51.5	62.5	53.5	63.5	54.5	65.0	56.5
5/16	38.0	23.5	55.0	43.5	58.5	47.5	60.0	50.0	62.0	52.0	63.0	53.0	65.0	55.5
3/8	36.0	22.0	53.5	41.0	57.5	45.0	59.0	48.0	61.0	50.0	63.0	52.0	65.0	54.5
7/16	34.0	21.0	52.0	38.5	56.5	42.5	58.0	45.5	60.0	48.0	62.5	50.0	64.5	53.0
1/2	33.0	20.5	50.0	36.0	55.0	40.0	57.0	43.0	59.5	45.5	62.0	48.0	64.0	51.0
9/16	31.5	...	48.0	34.0	54.0	37.5	56.0	41.5	58.5	43.5	61.0	46.0	64.0	49.0
5/8	30.0	...	47.0	32.0	52.5	36.0	55.0	39.5	58.0	41.5	60.5	44.0	63.5	47.0
11/16	29.5	...	45.5	31.0	51.5	34.0	54.0	37.5	57.0	40.0	59.5	42.5	63.0	45.0
3/4	28.5	...	44.5	29.5	50.0	33.0	53.0	36.0	56.0	38.5	59.0	41.0	62.5	43.5
13/16	28.0	...	43.0	28.5	49.0	32.0	52.0	35.0	55.0	37.0	58.5	39.5	62.0	42.0
7/8	27.0	...	42.5	28.0	48.0	31.0	51.0	34.0	54.5	36.0	58.0	38.5	61.5	40.5
15/16	26.5	...	41.5	27.0	47.0	30.0	50.0	33.0	53.5	35.0	57.0	37.5	61.0	39.5
1	26.5	...	41.0	26.5	46.0	29.5	49.0	32.0	52.5	34.0	56.5	36.0	60.0	38.5
1⅛	25.5	...	39.5	25.5	44.5	28.0	48.0	30.5	51.5	32.5	55.0	34.5	59.0	37.0
1¼	25.0	...	38.5	24.5	43.0	27.5	47.0	29.5	50.0	31.5	54.0	33.0	57.5	35.0
1⅜	24.5	...	38.0	24.0	42.5	27.0	46.0	29.0	49.5	30.5	53.0	32.5	56.5	34.0
1½	24.0	...	37.5	23.5	42.0	26.5	45.5	28.5	48.5	30.0	52.0	32.0	55.5	33.5
1⅝	23.5	...	37.0	23.0	41.5	26.0	45.0	28.0	48.0	30.0	51.5	31.5	55.0	33.0
1¾	23.5	...	36.5	23.0	41.0	25.5	44.5	28.0	47.5	29.5	51.0	31.0	54.5	33.0
1⅞	23.5	...	36.0	22.5	40.5	25.5	44.0	28.0	47.0	29.5	50.5	31.0	54.0	32.5
2	23.5	...	36.0	22.5	40.5	25.5	44.0	28.0	47.0	29.5	50.5	31.0	54.0	32.5

TABLE XIX

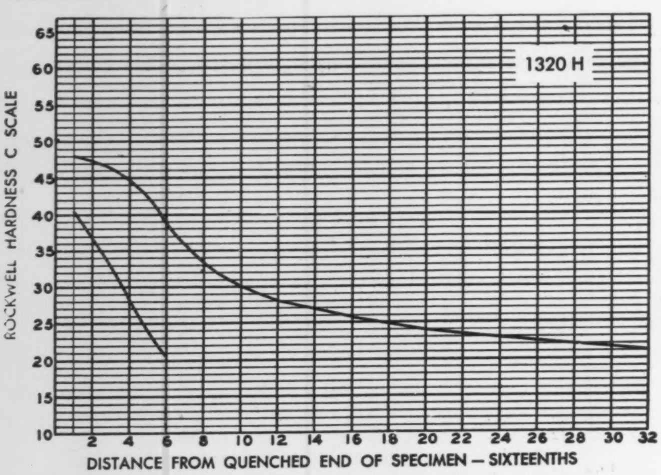
Tabulation of Hardenability Band Limits—9200 H Series

"J" Distance	Grade					
	9260 H		9261 H		9262 H	
(in.)	Max.	Min.	Max.	Min.	Max.	Min.
1/16	...	60.0	...	60.0	...	60.0
1/8	...	58.0	...	59.0	...	60.0
3/16	...	55.0	...	57.0	...	59.0
1/4	65.0	50.5	...	55.0	...	57.5
5/16	63.5	44.0	65.0	51.0	...	56.0
3/8	62.0	39.5	64.0	46.0	...	53.5
7/16	60.0	37.0	62.5	42.0	65.0	50.0
1/2	58.0	35.0	60.5	39.0	64.0	44.0
9/16	56.0	33.5	59.0	37.5	63.0	41.0
5/8	53.0	32.5	57.0	36.0	62.0	38.5
11/16	50.0	32.0	54.5	35.0	60.0	37.5
3/4	48.0	31.0	52.0	34.0	58.5	36.5
13/16	46.0	30.0	50.0	33.0	56.5	36.0
7/8	44.0	29.5	48.0	32.0	53.5	35.0
15/16	43.0	29.0	46.0	31.5	50.5	34.0
1	41.5	28.5	44.5	31.0	48.0	33.5
1⅛	40.0	27.5	42.5	30.0	45.0	32.5
1¼	38.5	26.5	41.0	29.5	43.5	31.5
1⅜	37.5	26.0	40.5	28.5	43.0	30.5
1½	37.0	25.5	40.0	28.0	42.5	30.0
1⅝	37.0	25.0	39.5	27.5	42.0	29.5
1¾	36.5	24.5	39.5	27.0	41.5	29.0
1⅞	36.0	24.0	39.0	26.5	41.5	28.5
2	36.0	24.0	39.0	26.0	41.0	28.0

TABLE XX

Standard Carbon Content Ranges for "H" Steels

Steel Number	Carbon Range (per cent)
1320 H	0.17/0.24
1330 H	0.27/0.34
1335 H	0.32/0.39
1340 H	0.37/0.45
2512 H	0.08/0.15
2515 H	0.11/0.18
2517 H	0.14/0.21
3310 H	0.07/0.14
3316 H	0.13/0.20
4130 H	0.27/0.34
4132 H	0.30/0.37
4135 H	0.32/0.39
4137 H	0.35/0.43
4140 H	0.37/0.45
4142 H	0.40/0.48
4145 H	0.42/0.50
4147 H	0.44/0.52
4150 H	0.46/0.54
4317 H	0.14/0.21
4320 H	0.16/0.23
4340 H	0.37/0.45
4620 H	0.17/0.24
4640 H	0.37/0.45
4812 H	0.10/0.17
4815 H	0.12/0.19
4817 H	0.14/0.21
4820 H	0.17/0.24
5140 H	0.37/0.45
5145 H	0.42/0.50
5150 H	0.46/0.54
6150 H	0.46/0.54
8617 H	0.14/0.21
8620 H	0.17/0.24
8622 H	0.20/0.27
8625 H	0.22/0.29
8627 H	0.25/0.32
8630 H	0.27/0.34
8632 H	0.30/0.37
8635 H	0.32/0.39
8637 H	0.35/0.43
8640 H	0.37/0.45
8641 H	0.37/0.45
8642 H	0.40/0.48
8645 H	0.42/0.50
8647 H	0.44/0.52
8650 H	0.46/0.54
8655 H	0.50/0.60
8660 H	0.55/0.65
8720 H	0.17/0.24
8735 H	0.32/0.39
8740 H	0.37/0.45
8742 H	0.40/0.48
8745 H	0.42/0.50
8747 H	0.44/0.52
8750 H	0.46/0.54
9260 H	0.55/0.65
9261 H	0.55/0.65
9262 H	0.55/0.65
9437 H	0.35/0.43
9440 H	0.37/0.45
9442 H	0.40/0.48
9445 H	0.42/0.50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65
60
55
50
45
40
35
30
25
20
15
10
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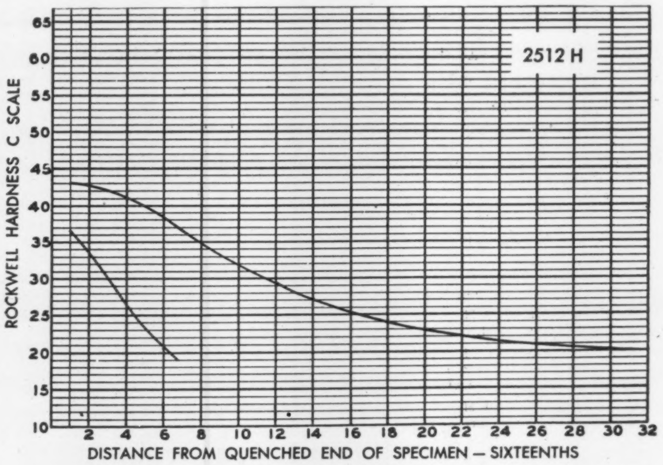
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS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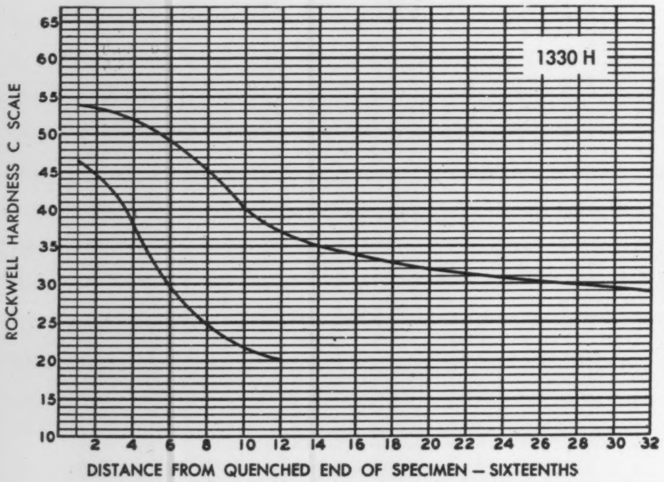
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS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25
20
15
10
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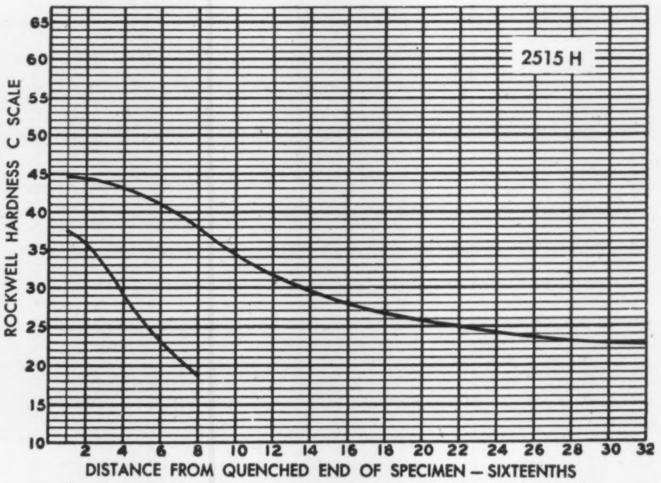
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS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50
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30
25
20
15
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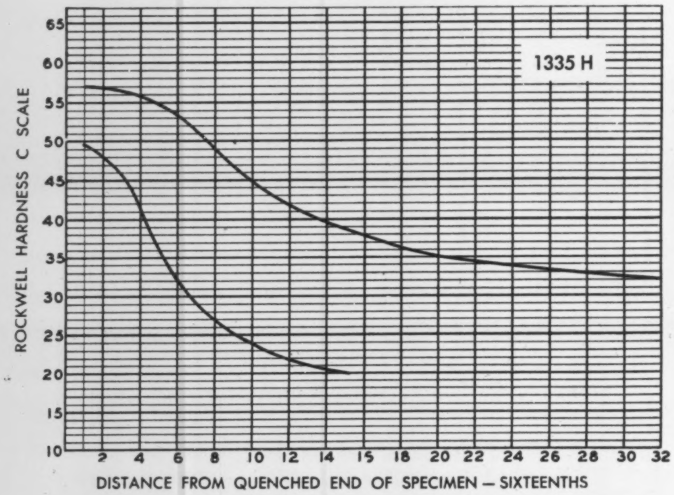
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS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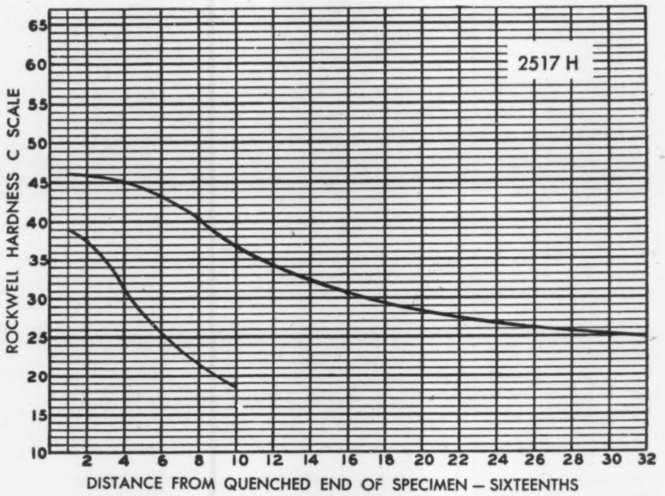
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS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50
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25
20
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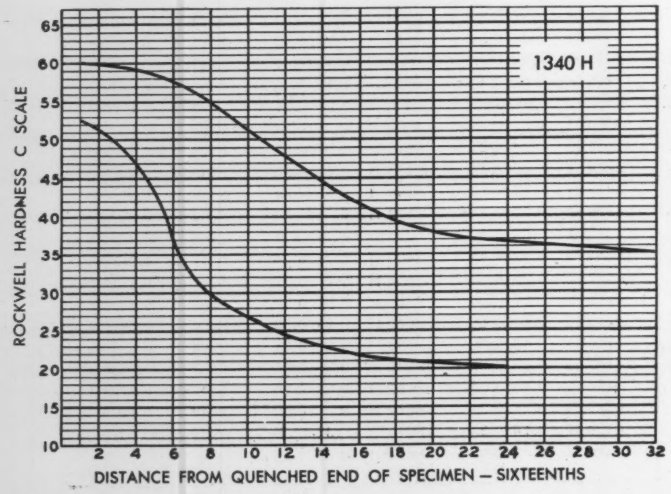
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS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ROCKWELL HARDNESS C SCALE
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50
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25
20
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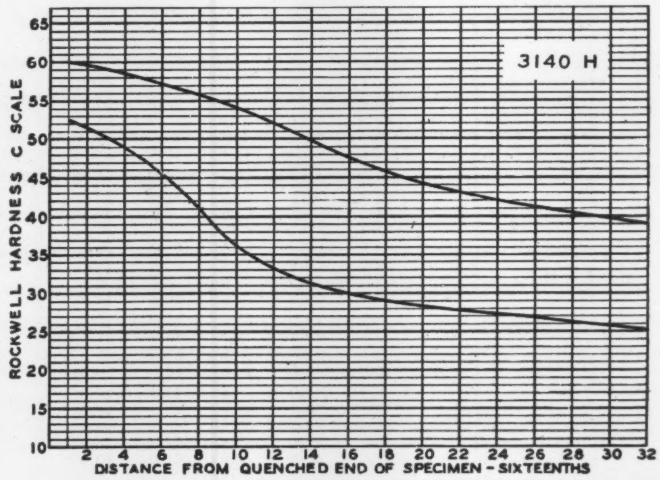
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS


3140 H
ROCKWELL HARDNESS C SCALE
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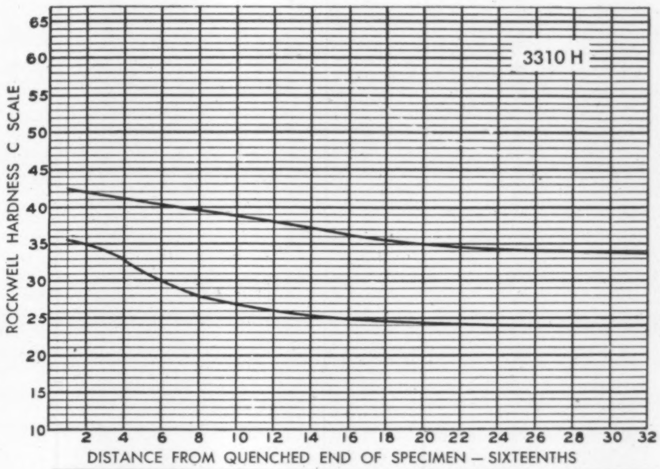
60
55
50
45
40
35
30
25
20
15
10
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
DISTANCE FROM QUENCHED END OF SPECIMEN - SIXTEENTHS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20
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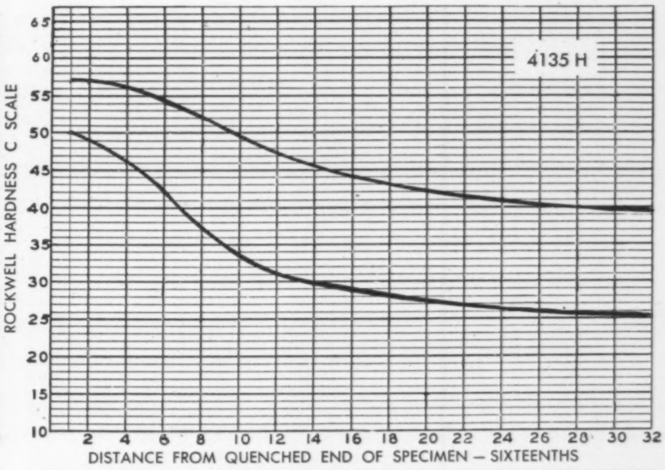
DISTANCE FROM QUENCHED END OF SPECIMEN – SIXTEENTHS


4135 H
ROCKWELL HARDNESS C SCALE
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60
55
50
45
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35
30
25
20
15
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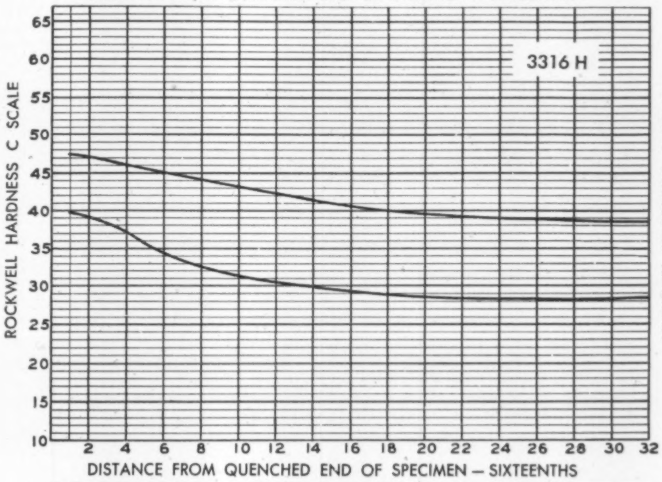
DISTANCE FROM QUENCHED END OF SPECIMEN – SIXTEENTHS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ROCKWELL HARDNESS C SCALE
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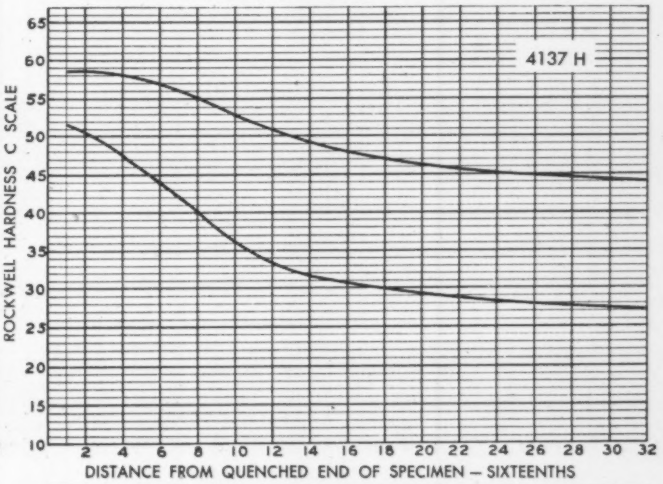
DISTANCE FROM QUENCHED END OF SPECIMEN – SIXTEENTHS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ROCKWELL HARDNESS C SCALE
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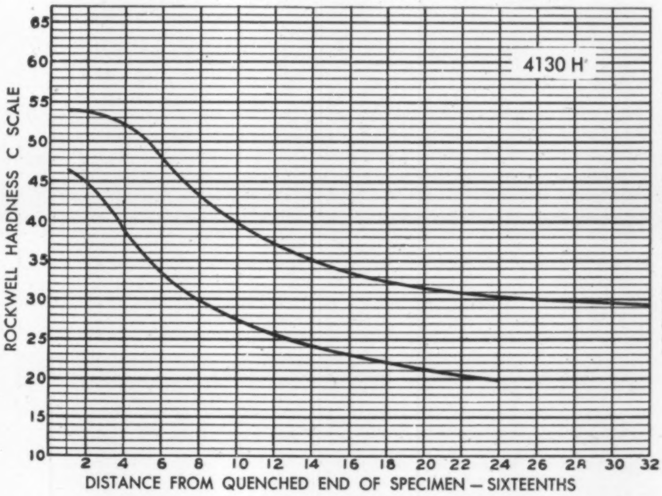
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
DISTANCE FROM QUENCHED END OF SPECIMEN – SIXTEENTHS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ROCKWELL HARDNESS C SCALE
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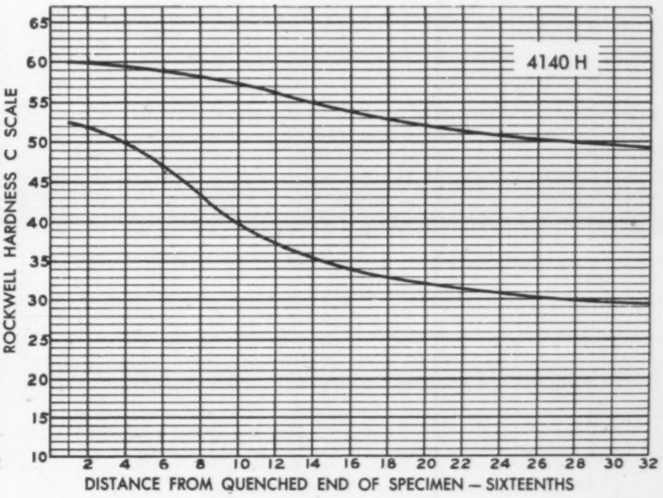
DISTANCE FROM QUENCHED END OF SPECIMEN – SIXTEENTHS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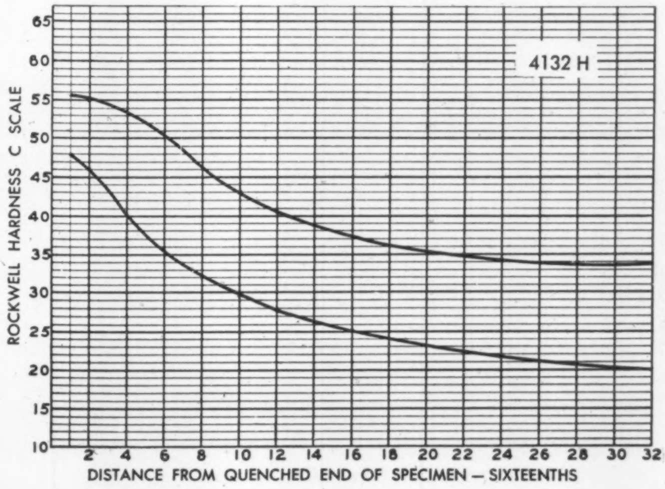
DISTANCE FROM QUENCHED END OF SPECIMEN – SIXTEENTHS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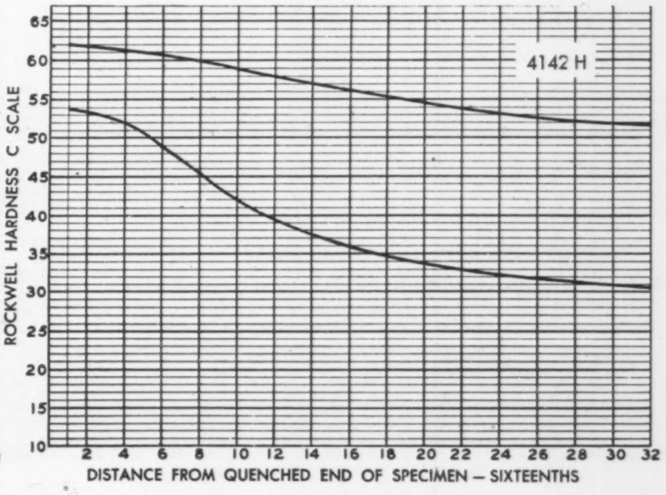
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
DISTANCE FROM QUENCHED END OF SPECIMEN – SIXTEENTHS


4142 H
ROCKWELL HARDNESS C SCALE
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60
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50
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20
15
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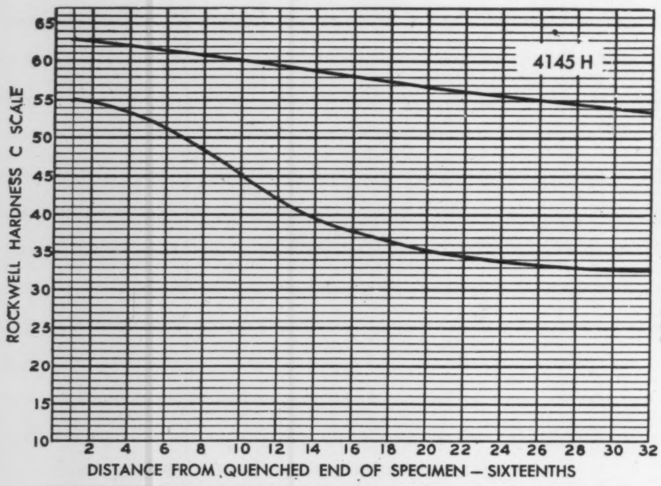
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
DISTANCE FROM QUENCHED END OF SPECIMEN – SIXTEENTHS


4145 H
ROCKWELL HARDNESS C SCALE
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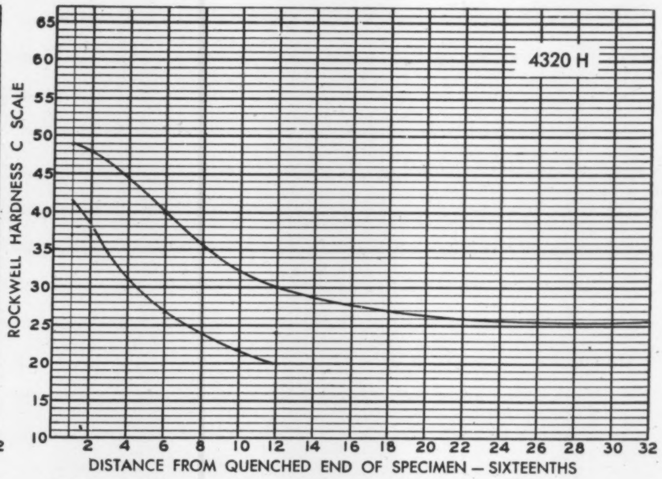
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS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ROCKWELL HARDNESS C SCALE
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2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
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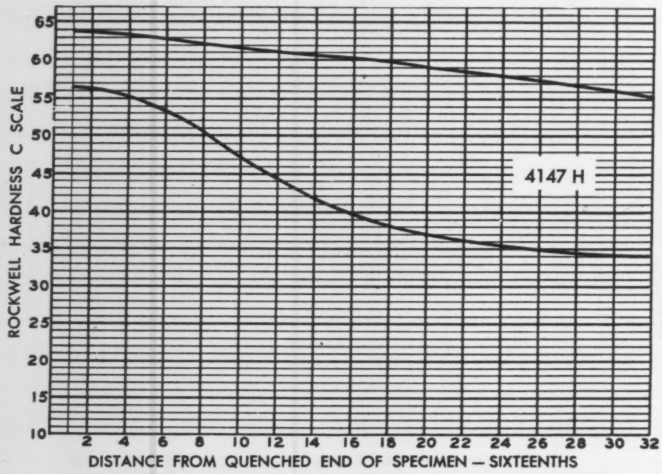
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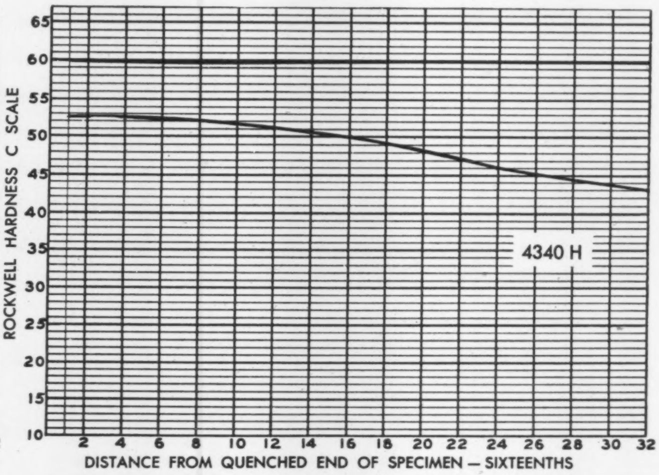
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ROCKWELL HARDNESS C SCALE
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2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
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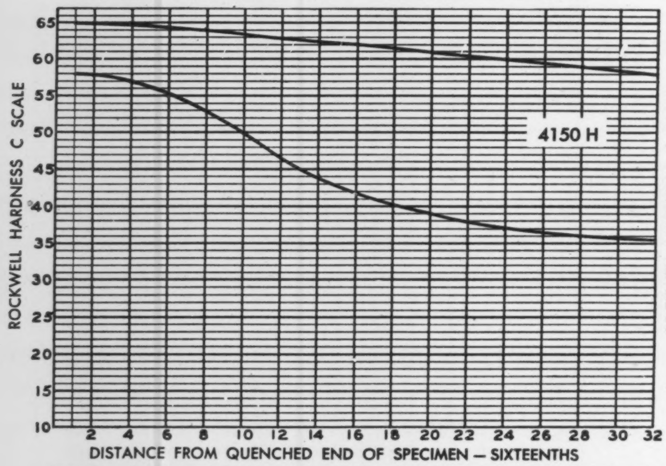
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ROCKWELL HARDNESS C SCALE
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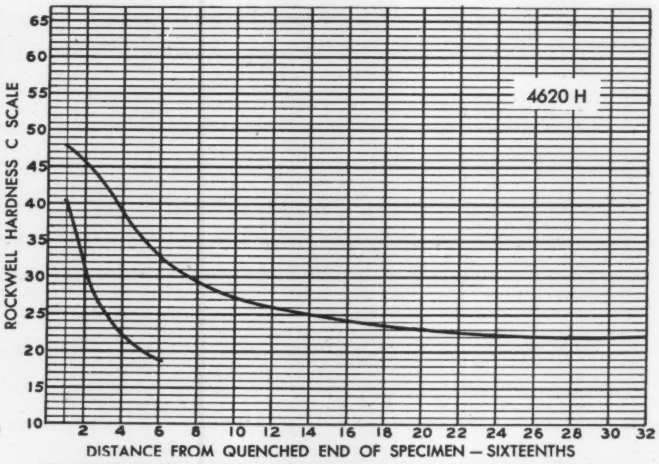
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS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2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
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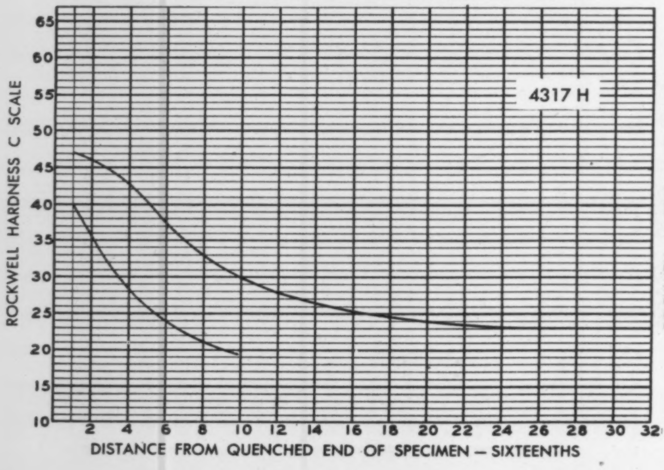
4317 H
ROCKWELL HARDNESS C SCALE
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2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
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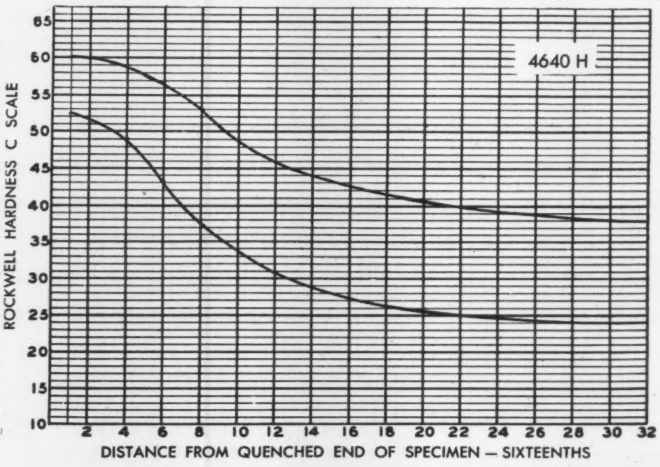
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ROCKWELL HARDNESS C SCALE
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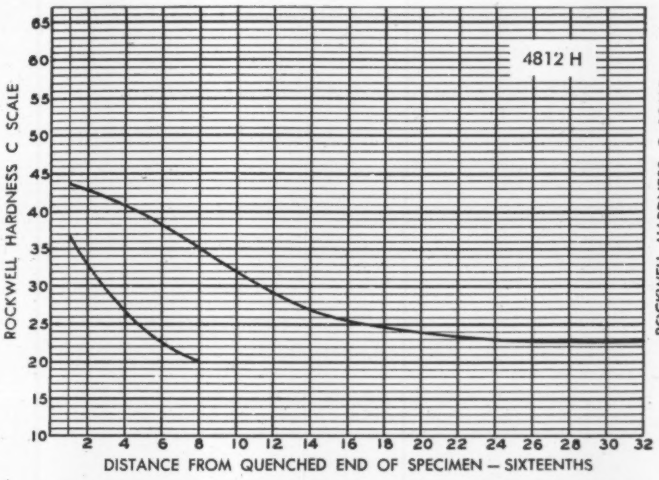
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65
60
55
50
45
40
35
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25
20
15
10
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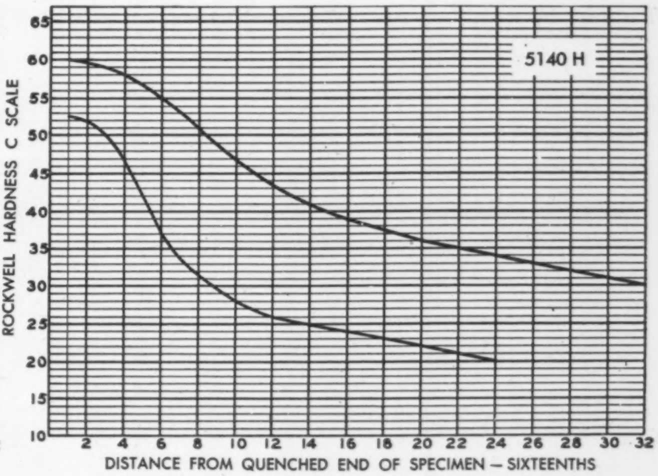
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS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ROCKWELL HARDNESS C SCALE
65
60
55
50
45
40
35
30
25
20
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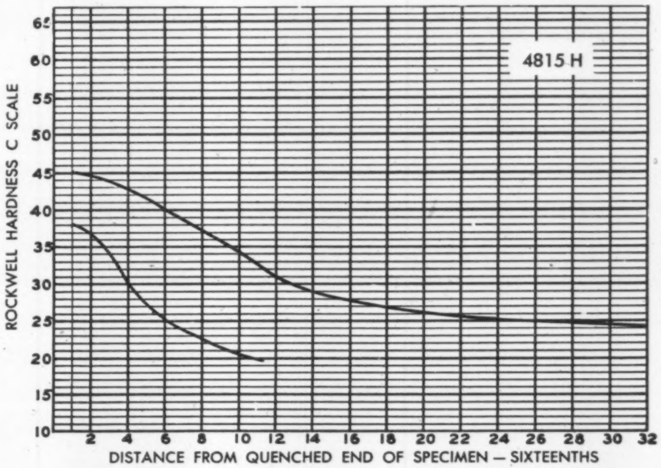
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS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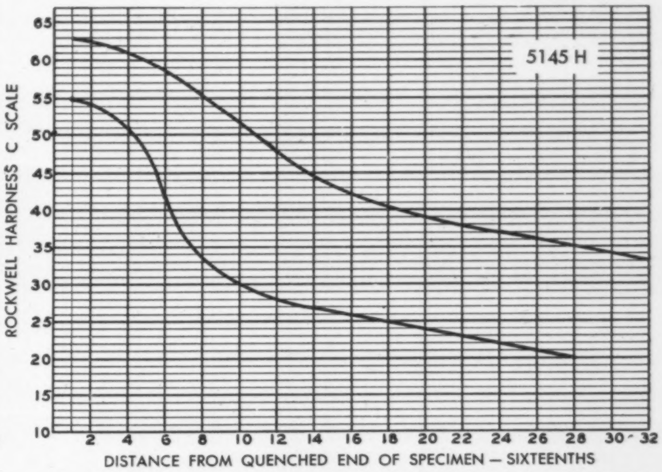
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS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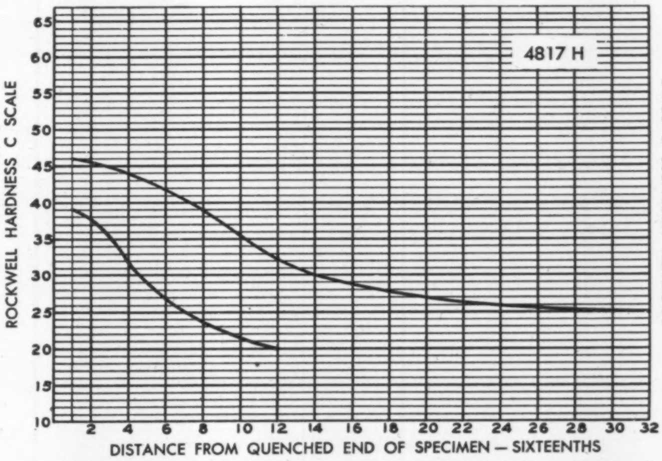
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS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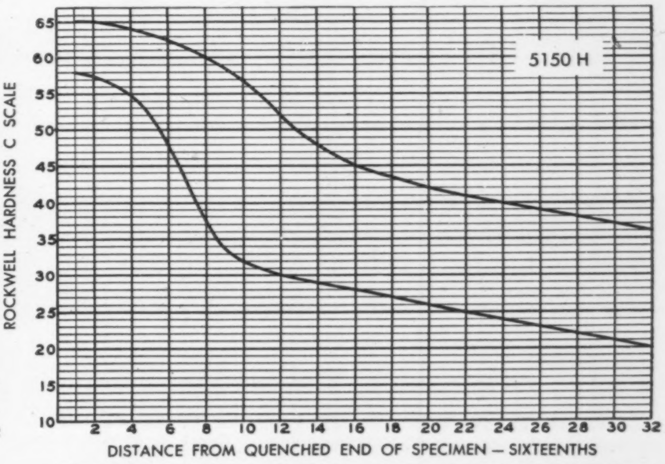
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS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ROCKWELL HARDNESS C SCALE
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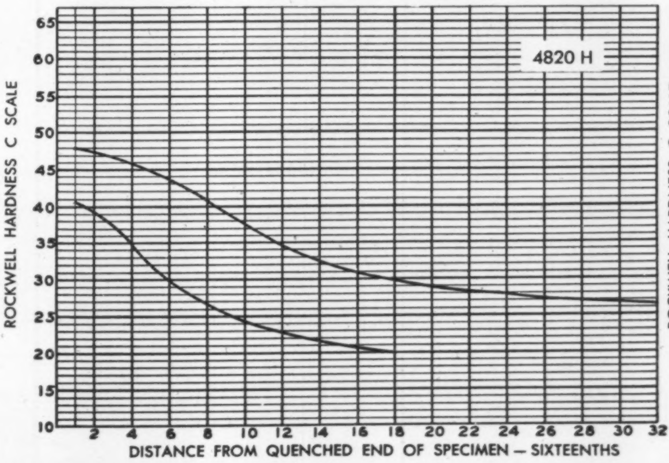
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS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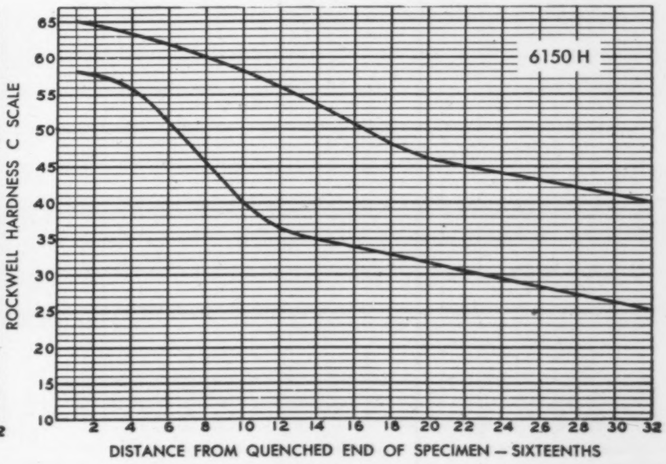
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS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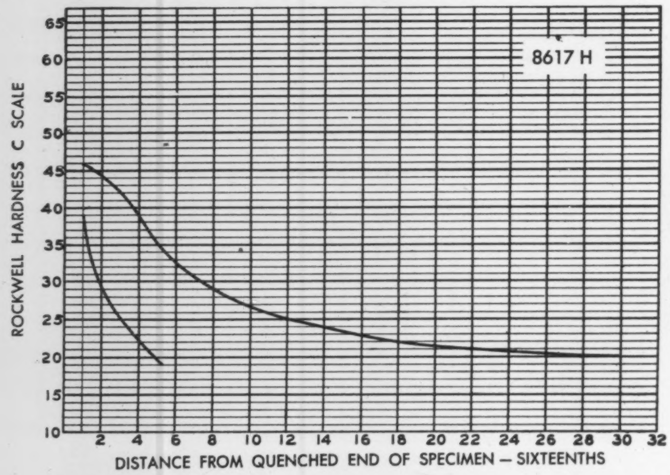
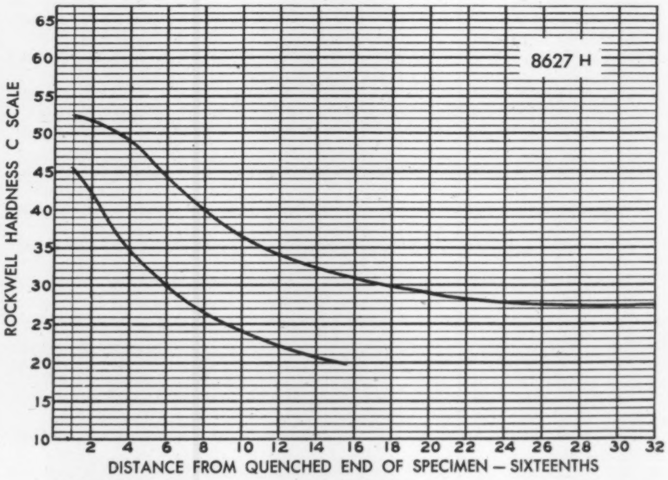
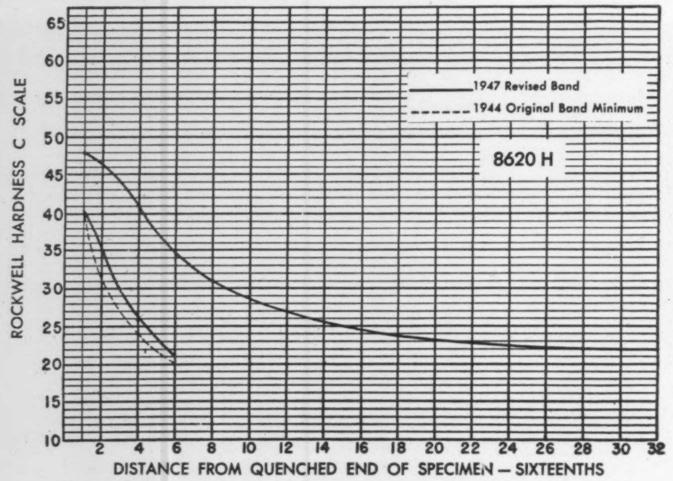
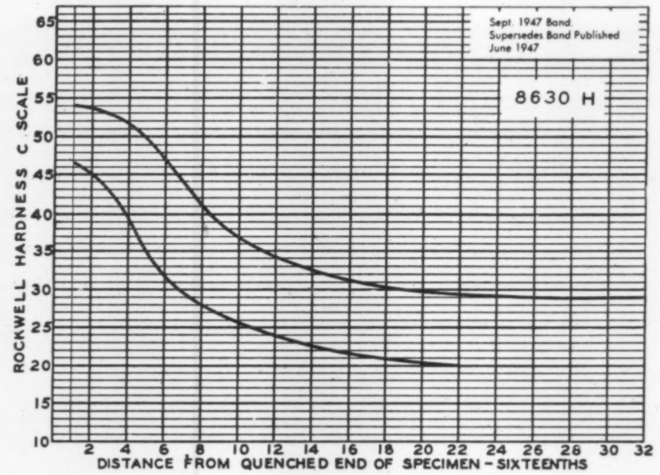
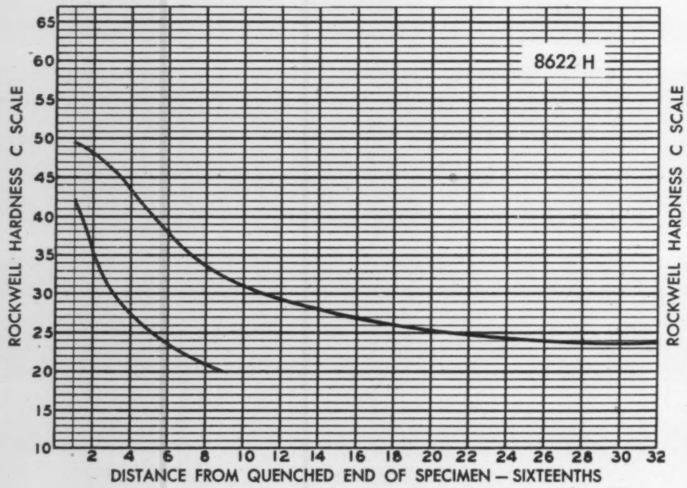
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS

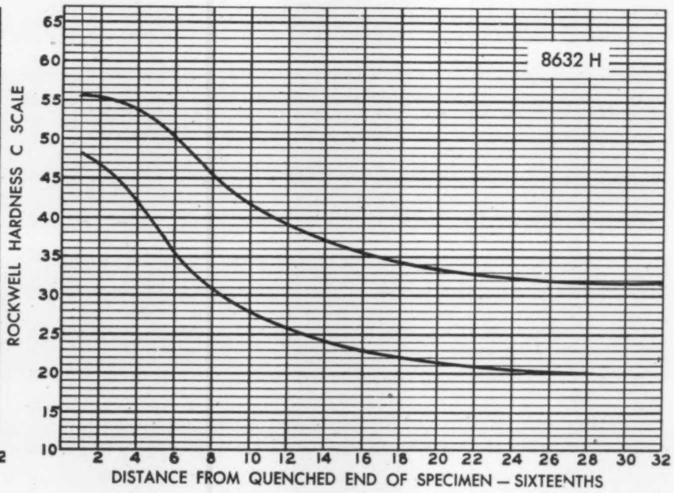


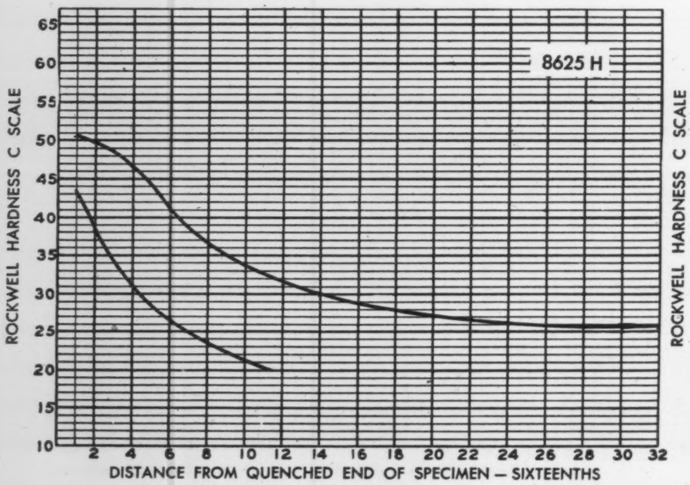


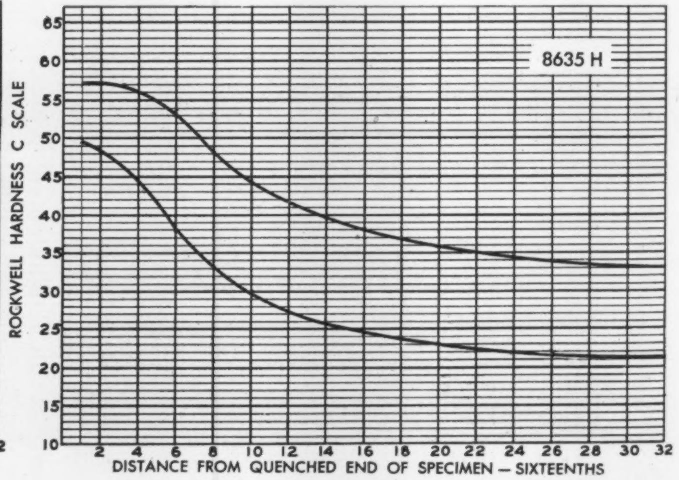


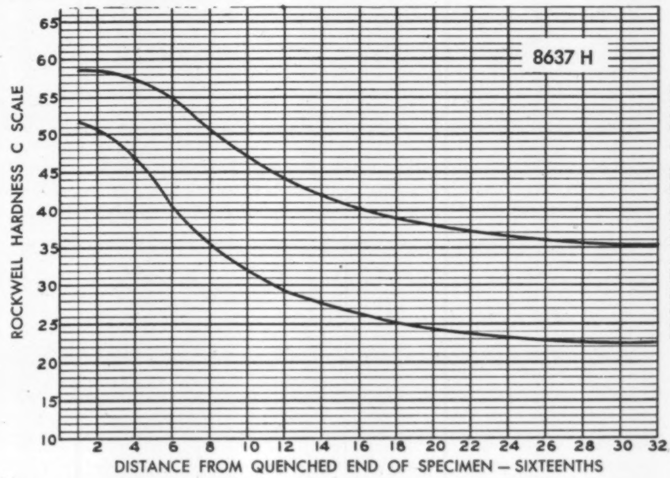

Sept. 1947 Band Supersedes Band Published June 1947







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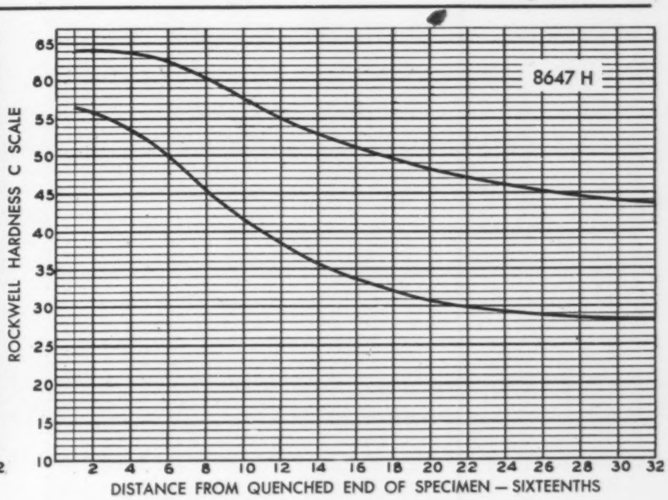
DISTANCE FROM QUENCHED END OF SPECIMEN – SIXTEENTHS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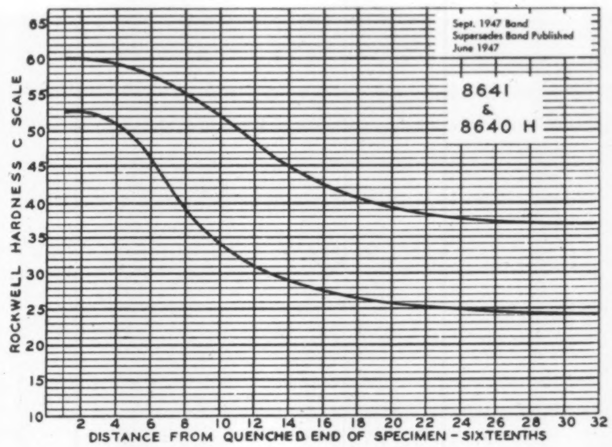
DISTANCE FROM QUENCHED END OF SPECIMEN – SIXTEENTHS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Supersedes Band Published
June 1947
8641
&
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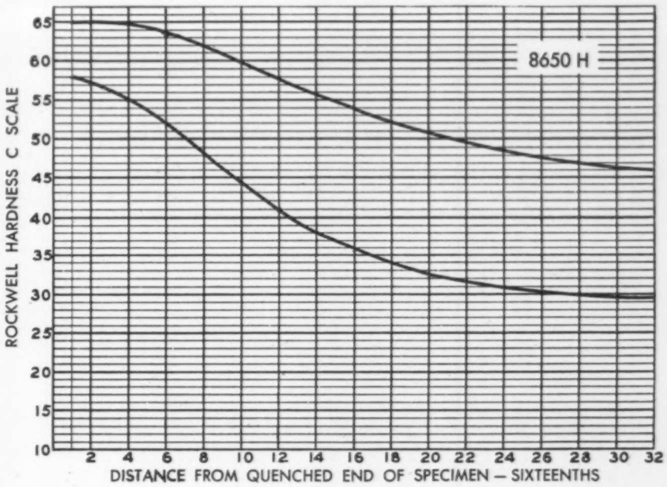
DISTANCE FROM QUENCHED END OF SPECIMEN – SIXTEENTHS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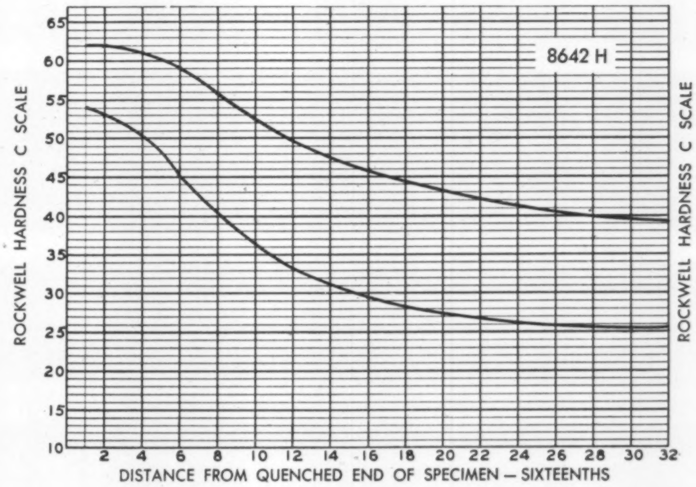
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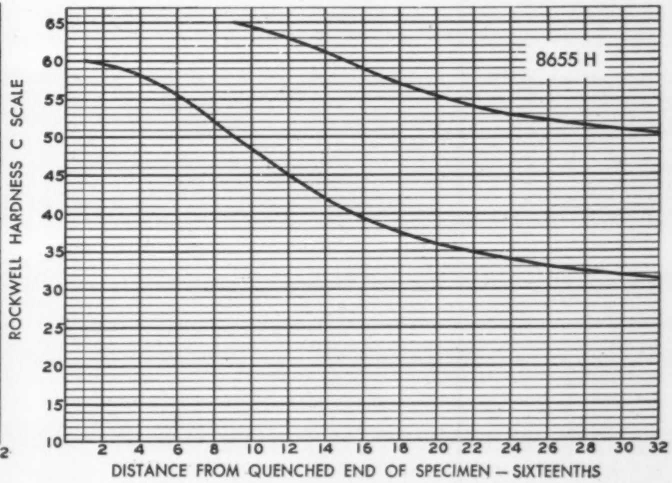
DISTANCE FROM QUENCHED END OF SPECIMEN – SIXTEENTHS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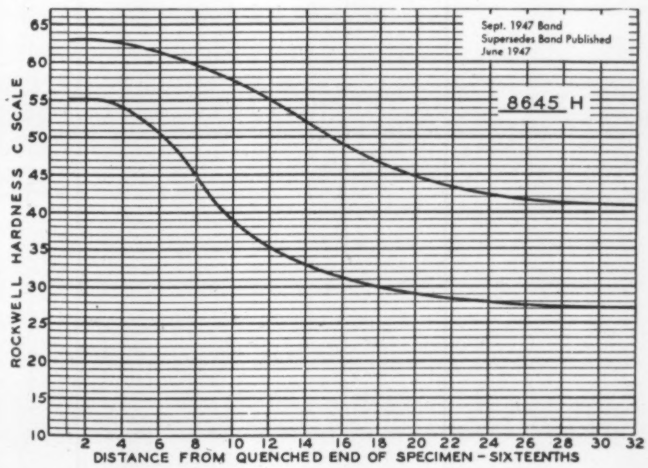
DISTANCE FROM QUENCHED END OF SPECIMEN – SIXTEENTHS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Supersedes Band Published
June 1947
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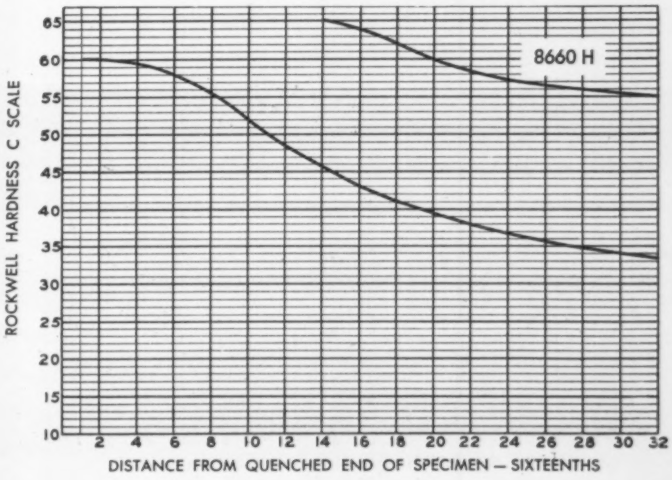
DISTANCE FROM QUENCHED END OF SPECIMEN – SIXTEENTHS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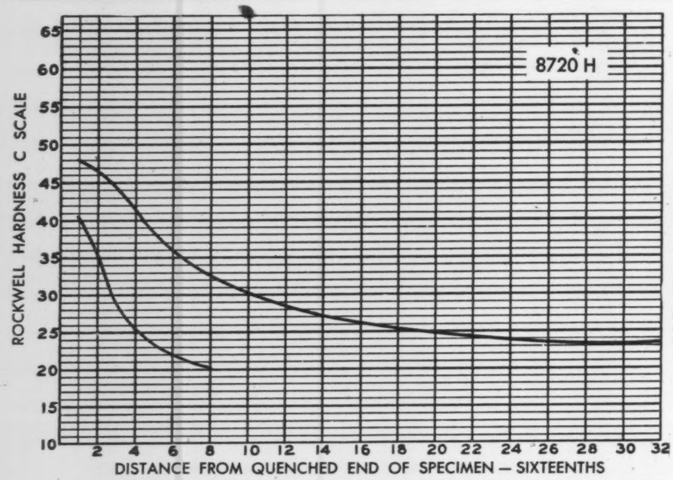
DISTANCE FROM QUENCHED END OF SPECIMEN – SIXTEENTHS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ROCKWELL HARDNESS C SCALE
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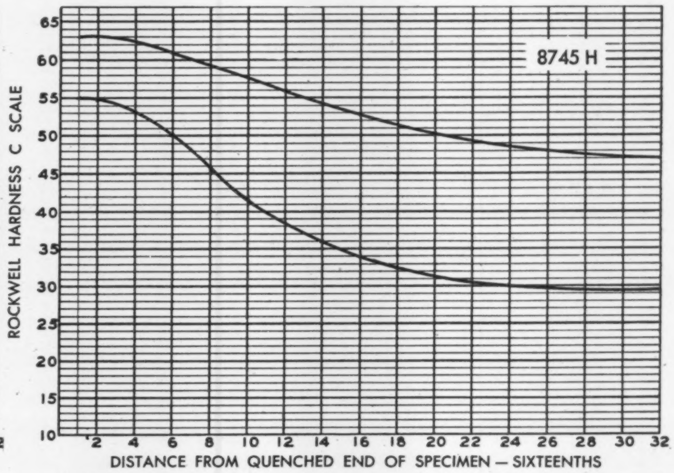
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS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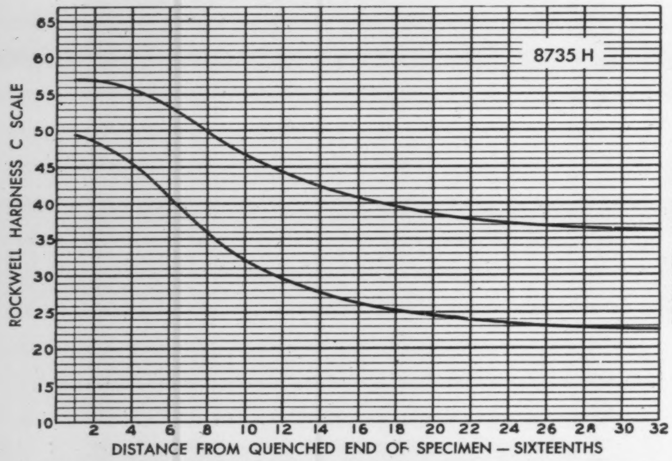
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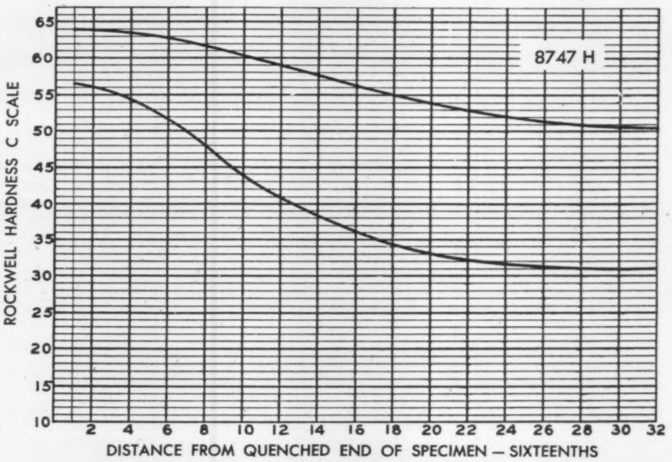
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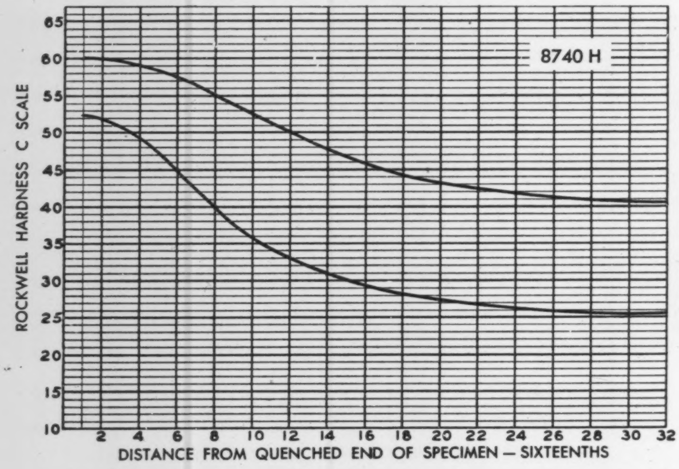
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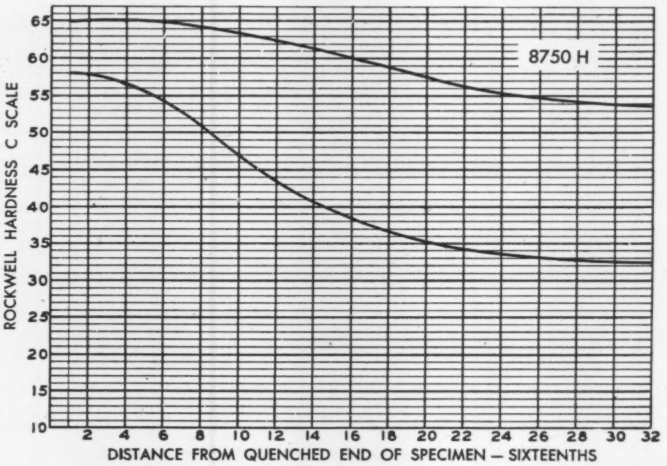
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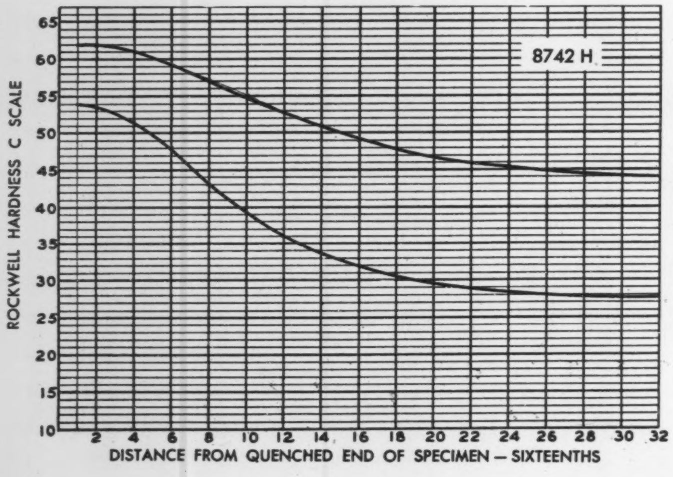
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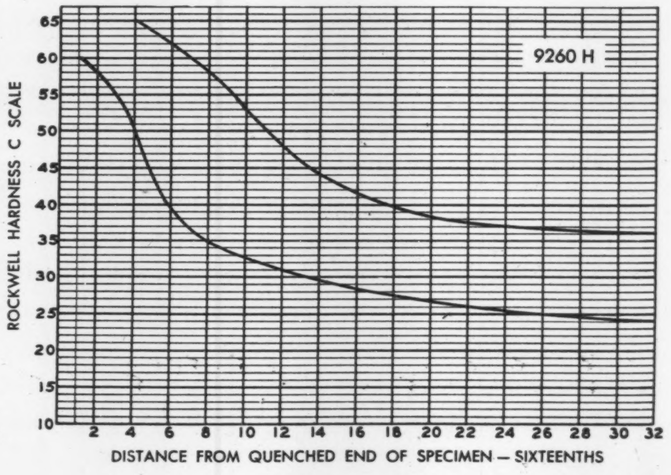
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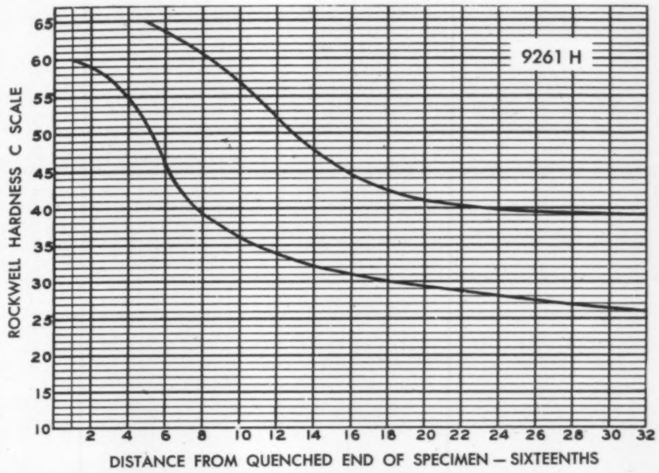
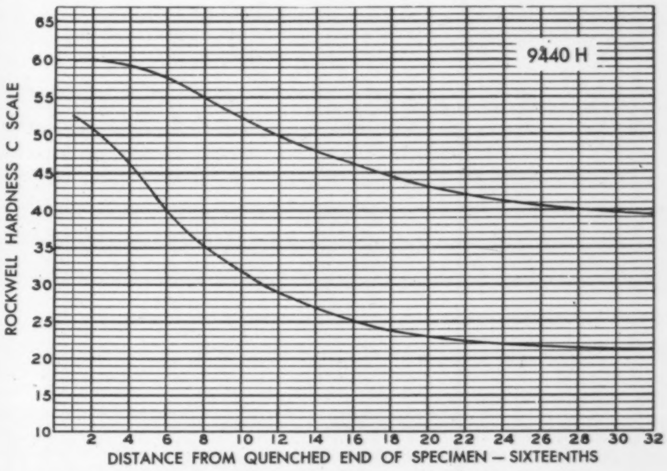
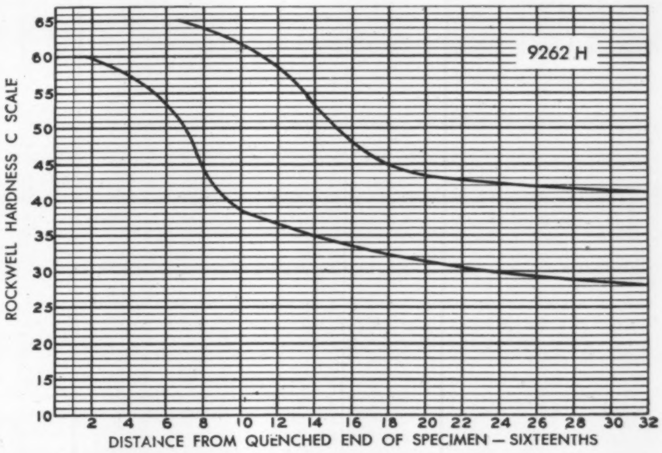
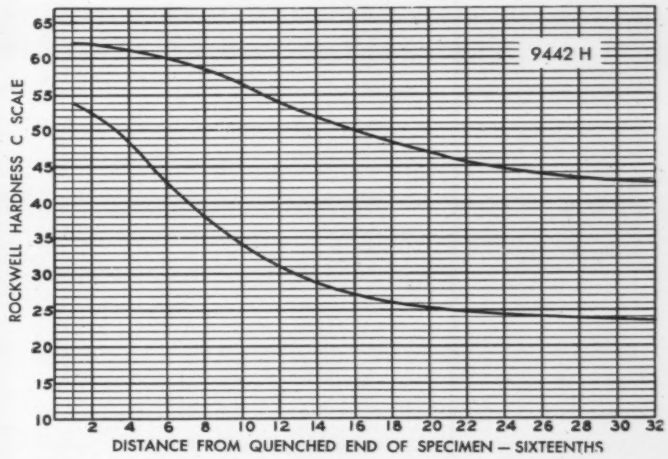
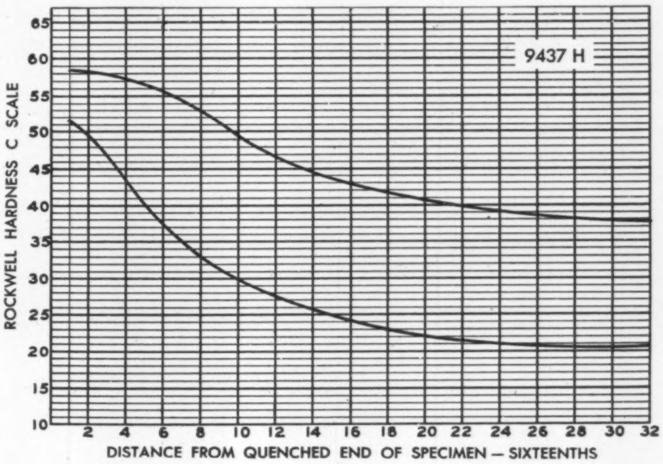
DISTANCE FROM QUENCHED END OF SPECIMEN — SIXTEENTHS

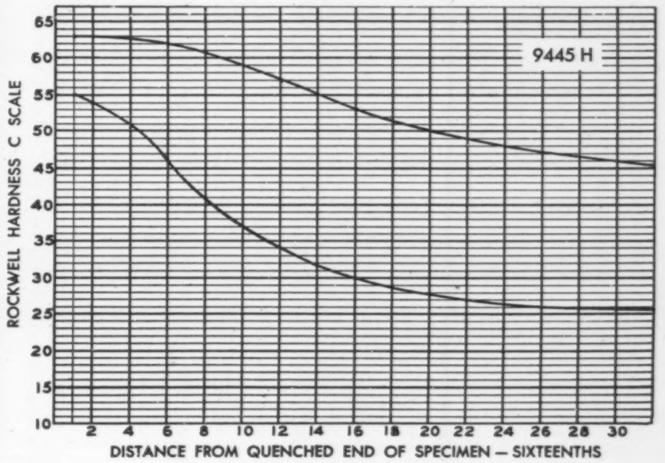












A practical procedure for selecting a substitute steel for an existing part is clearly described in the excellent paper "Selection of Automotive Steel on the Basis of Hardenability" by A. L. Boegehold. This paper originally appeared in the S.A.E. Journal, October, 1944, and has been reprinted in full in the book "Hardenability of Alloy Steels" currently available from the American Iron and Steel Institute, 350 Fifth Ave., New York 1.

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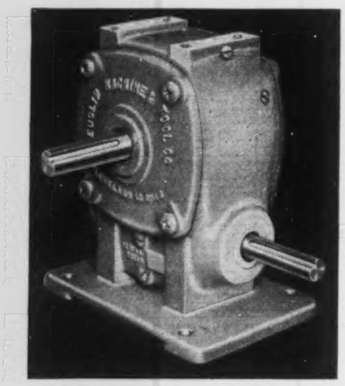
new parts and materials

To obtain additional information on these new developments see Page 243

Fractional-Horsepower Speed Reducers



Line of compound and single-reduction speed reducers is available in output torques to 1000 lb-in., and reduction ratios to 1200:1. Four models are single-reduction types and three compound-reduction styles. No. 0 is a single-reduction worm-gear reducer with 1.333-inch center distance. It is available in four ratios from 2:1 to 40:1. No. 2½, with 1.75-inch center distance, is made in ratios from 7½:1 to 50:1; while No. 5, with 2-inch centers, is made in eight ratios from 9:1 to 60:1. The largest single-reduction unit has a 2.625-inch center distance and is available in nine ratios ranging from 10:1 to 96:1. The compound reducers, Numbers CW-0 CW-1 and SCW-1, are all available with twenty-four reduction ratios, ranging to 1200:1 for the two latter models which are rated at 350 lb-in. output torque. The reducers all incorporate 20-degree pressure-angle gears, cast-aluminum alloy housings and use roller-bearings throughout. Manufacturer: Euclid Machine & Tool Co., 15004 Woodworth Ave., Cleveland 10.

For further information circle MD 1 on Page 243

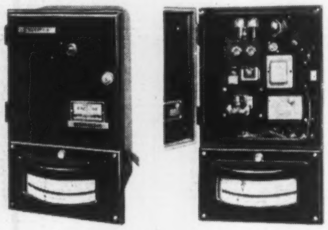
Large Forged Nuts

Hex and square nuts in sizes starting at 3 inches are available in quantity. Providing high fatigue resistance which makes them desirable for dependable service and long life, these fasteners are particularly useful for large machinery. They are accurately forged and have milled threads made to either standard or special dimensions. Manufacturer: Joseph Dyson & Sons, Inc., 5125 St. Clair Ave., Cleveland 4.

For further information circle MD 2 on Page 243

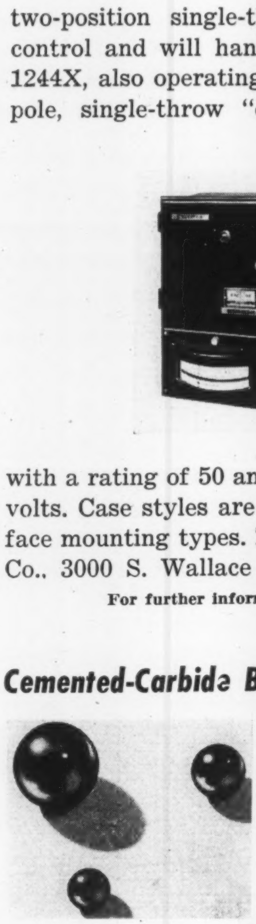
Temperature-Control Instrument

Combining in one complete unit the Wheelco Capacitrol and the Xactline control, new Xactline Capacitrol temperature controller will hold temperature within 1/5-degree F with on-off cycles as short as three seconds. Unit uses no gears, motors or other mechanical devices, is electronic in principle. Controller is available in two models: Model 1241X has a two-position single-throw, double-pole Micro-Switch control and will handle 10 amp at 320 volts. Model 1244X, also operating on 115 or 230 volts, has single-pole, single-throw "on-off" mercury-switch control, with a rating of 50 amp at 115 volts, or 25 amp at 230 volts. Case styles are available in either flush or surface mounting types. Manufacturer: Claude S. Gordon Co., 3000 S. Wallace St., Chicago 16.



For further information circle MD 3 on Page 243

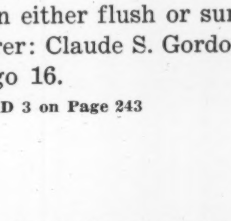
Cemented-Carbide Balls



Carboloy balls ground to tolerances of 0.0002-inch in diameter are recommended for such applications as ball check valves. The balls, standard in Carboloy grade 44A, are available in ten standard sizes ranging from ⅛ to 1 inch in diameter, and are said to combine great toughness with good resistance to wear. Manufacturer: Carboloy Co. Inc., 11113 East 8 Mile Road, Detroit 32.

For further information circle MD 4 on Page 243

Immersion Thermostats



Immersion type thermostat line is designed to regulate the temperature of liquids in all types of containers or systems. The L-578 series thermostat consists of four parts: Well, which is fixed to the liquid container and which makes possible the easy removal of the mechanism without leakage, temperature-sensitive bimetal element which fits within the well, a mercury-to-mercury switch operated by the bimetal element,

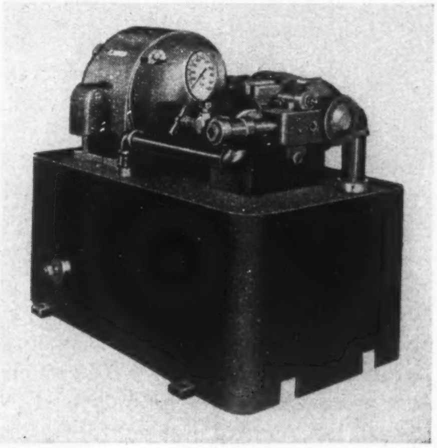
Wichita City Libr

and a temperature-setting mechanism. As fluid temperature increases, the bimetal element expands and causes the mercury switch to be tilted. Temperature setting is the point at which the mercury switch becomes tilted sufficiently to either open or close the electrical circuit. Three models are included in the series, all rated at either 15 amp, 115 volts ac, or 10 amp, 230 volts ac and suitable for operation in the temperature range 100 to 300 F with a 10-degree operating differential. Model L-578-1 has a single-pole, single-throw switch breaking contact on temperature rise. Model L-578-2 has single-pole, single-throw switch making contact on temperature rise. Model L-578-3 has a single-pole, double-throw switch which breaks or makes contact on temperature rise depending on terminal connections used. Manufacturer: General Controls Co., Box 1431, Glendale 1, Calif.

For further information circle MD 5 on Page 243

Hydraulic Power Unit

Standardized hydraulic power units for use in conjunction with hydraulic cylinders and other hydraulic equipment will produce pressures to 2000 psi and above. The complete package consists of pump, pressure relief and adjusting valve, motor and hydraulic pressure gage. Units, available for volumes from 1 gpm up, are distinguished by their excellent styling and compactness. Manufacturer: Hannifin Corp., 1101 S. Kilbourn Ave., Chicago.



For further information circle MD 6 on Page 243

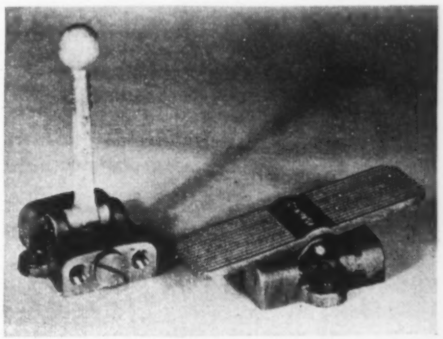
Protective Coating for Aluminum

Chemical protective coating for aluminum and its alloys, Alodine is applied rapidly and without use of electricity, will stand 2000-hour exposure to salt atmosphere. Interaction of aluminum and the Alodizing chemicals produces integral coating which is flexible and chemically stable and which will stand extreme bending and denting without failure. The protective coating, applied in two minutes, is not an oxide type finish and can be used either painted or unpainted. It requires no priming coat when paint is applied. Manufacturer: American Chemical Paint Co., Ambler, Pa.

For further information circle MD 7 on Page 243

Poppet-Type Air Valve

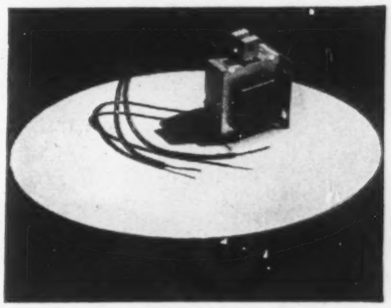
Small, poppet type air valve, available in either hand or foot-operated models, is designed for control of light production equipment. Constructed of stainless-steel and brass with a Hi-Carb Neoprene seat, valve is available in 12 styles. In foot-treadle units, No. 600 is a 3-way valve while No. 601 is 4 way. In the hand-lever types, No. 602 is 3 way, while No. 603 is 4 way. All valves are available in locking, nonlocking or neutral-position types. Manufacturer: Ross Operating Valve Co., Dept. K, 6485 Epworth Blvd., Detroit 10.



For further information circle MD 8 on Page 243

Short-Stroke Solenoid

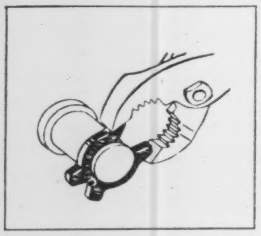
Small, all-welded solenoid for use where powerful pull is needed in a small space, develops a maximum pull of 0.26-lb in a half-inch stroke. It operates on 110-volt, 60-cycle power. An L-shaped mounting bracket permits either horizontal or vertical mounting and frame and bracket are welded together for sturdiness and long life. Frame laminations are silicon steel permitting more pull per watt input. The removable coil, which is paper wound and plastics impregnated, is sealed inside a plastics housing. Unit



is recommended for such applications as appliances, pinball machines, trip mechanisms and vending machines. Manufacturer: General Electric Co., Control Division, Schenectady, N. Y.

For further information circle MD 9 on Page 243

X-Washers



Single-piece locking units which may be quickly clamped around pins, new series of X-washers form 60-degree closure to support heavy thrust loads. The easily applied or removed fasteners are manufactured from cold-rolled steel and cadmium plated, in sizes to fit pins from 7/32 to 17/32-inch in diameter. Manufacturer: Standard Locknut and Lockwasher, Inc., 311 North Capitol Ave., Indianapolis.

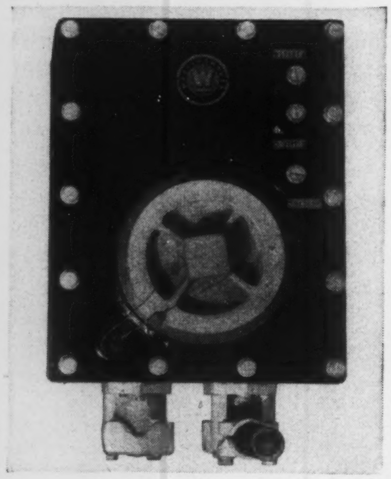
For further information circle MD 10 on Page 243

New Thermoplastic

Providing toughness and flexibility, new plastics is a colloidal blend of polyvinyl chloride resins and nitrile rubber polymers. Material, known as Geon Polyblend 500 x 503, is unique in that the characteristics of vinyl elastomers are achieved with no liquid plasticizer. The plastics is thus unusually stable in the presence of solvents. Manufacturer: B. F. Goodrich Chemical Co., 324 Rose Bldg., Cleveland 15.

For further information circle MD 11 on Page 243

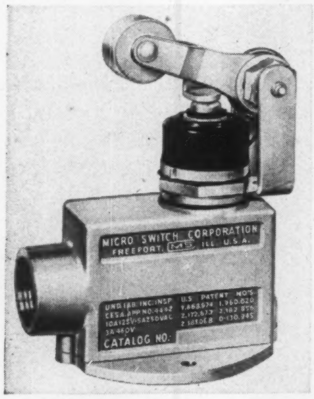
Explosion-Tested Linestarter



Direct - current linestarter for use with motors up to 5 hp in size on circuits of 80, 115, 230 and 550 volts is designed for use with U. S. Bureau of Mines approved "Permissible" equipment. The starter is equipped with magnetic blowouts that quickly rupture the arc and minimize burning of contact tips. Overload protection is provided by an inverse time-limit thermal-overload relay that permits moderate overloads but acts instantaneously if load is sufficient to damage the motor. New unit features sturdy dc magnetic contactor with knife-edge bearings. It has packing glands that can be bolted in place, permitting the assembly of conduit and gland away from the starter and then bolting the assembled unit in place. Overload relay can be arranged for either manual or automatic resetting. Short-circuit protection is provided by a fuse of such rating that it will not break the circuit on ordinary overload of the starting inrush current. All operating machinism is enclosed in a welded cabinet of heavy steel plate and pushbutton and reset button are mounted in the cover. Pushbutton may be located remotely if desired. Manufacturer: Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30.

For further information circle MD 12 on Page 243

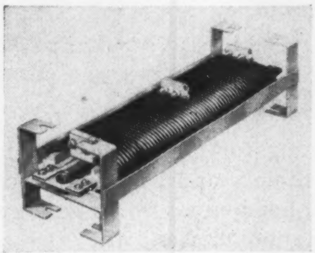
Sealed Snap-Action Switch



Roller-arm actuator type of snap switch sealed for operation when exposed to dust, dirt, abrasives and fluid splashing, is designed particularly for cam and slide actuation in industrial applications. Roller arm actuator is adjustable both vertically and horizontally and switch is supplied for either bottom or side mounting. This type N2 unit is equipped with synthetic rubber boot covering the operating plunger which together with a gasket between the bottom plate and housing case, provides a completely-sealed switch assembly. Operating at a force of from 6 to 16 ounces on a 0.006-inch differential, the entire assembly weighs only 0.64-lb mounted in its die-cast housing. Manufacturer: Micro Switch Div., First Industrial Corp., Freeport, Ill.

For further information circle MD 13 on Page 243

High-Capacity Resistors



Wire-wound resistors for use in motor starting and dynamic braking, as well as for field discharge and plugging are rated at 2200 watts, continuous duty. The sturdily constructed units have resistances from 0.32 to 4.35 ohms with continuous current capacities from 21 to 79 amperes. Units of these Edgeohm resistors having a duty cycle of 5 seconds out of 8 seconds are rated at 17,000 watts based on a 375-degree temperature rise. Single resistors are available with stamped steel brackets while multiple units up to four can be furnished in a single open frame. Frames of the same length and width may be stacked in banks. Manufacturer: Ward Leonard Electric Co., Mount Vernon, N. Y.

For further information circle MD 14 on Page 243

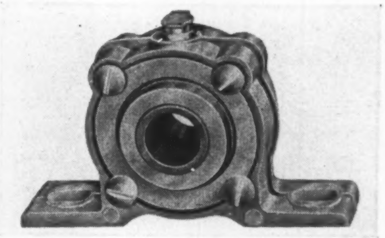
Vibration Mount

Designed for conditions where low frequency permits a mount having large deflection, No. 140 series Vibration Eliminator has static deflections up to ½-inch. The rubber-type mount is available for loads between 100 and 400 lb, will assure isolation at frequencies as low as 600 cpm. Manufacturer: Vibration Eliminator Co., 10-28 47th Ave., Long Island City 1, N. Y.

For further information circle MD 15 on Page 243

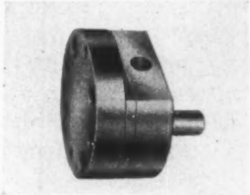
Pillow-Block Bearing

Self-aligning pillow-block bearings have self-lubricating feature providing adequate lubrication over long periods. Bearing has a porous-bronze sleeve surrounded by a large, felt, oil reservoir, eliminating the necessity for frequent oiling. While completely self aligning the pillow block is anchored firmly in place. Use of new alloys in bearing greatly increases life. Sizes readily available include: ⅝, ¾, ⅞, 1 and 1 3/16 inch. Other sizes from ½ to 1⅛ inch can be made to order. Manufacturer: Western Thermal Equipment Co., 1701 W. Slauson St., Los Angeles.



For further information circle MD 16 on Page 243

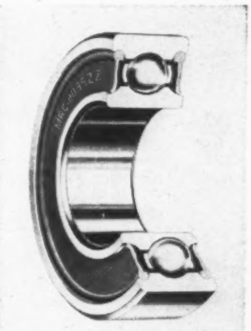
Gear Pump for Lubrication Systems



Low-capacity gear pumps designed to provide 50 cu cm per minute when driven at 100 rpm, deliver correct quantity of lubricant without by-passing a large percentage of the output. High-efficiency units, the pumps maintain a constant feed under high pressure during operation of machine. They are made in three models: Universal type, illustrated, can be mounted in any position, the direction of drive-shaft rotation determining the direction of flow. Reversible pump maintains flow in one direction only regardless of change of drive-shaft rotation during operation. The sump-type gear pump is equipped with an integral fine-mesh screen and may be mounted directly in the sump. Because of their compact size—base diameter 2½ inches—the gear pumps are readily incorporated in designs where space limitations exist. Manufacturer: Bijur Lubricating Corp., 43-01 22nd St., Long Island City 1, N. Y.

For further information circle MD 17 on Page 243

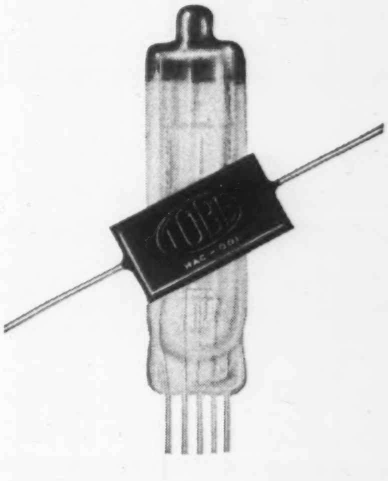
Sealed Ball Bearing



Soft Synthetic-Rubber seal having steel core is used on new line of bearings to retain the lubricant and exclude foreign material. Being of elastic material, the single-piece replaceable seal adjusts itself to the shape of the rubbing surface thus assuring positive, tight closure. Seal material is water and oil resistant and will function in the temperature range −30 F to 225 F. Removal of one seal makes the bearing usable in single-seal applications. These Synthe-Seal bearings are manufactured in Standard SAE single-row bores, diameters and widths in most of the popular sizes. Manufacturer: Marlin-Rockwell Corp., Jamestown, N. Y.

For further information circle MD 18 on Page 243

Miniature Capacitors

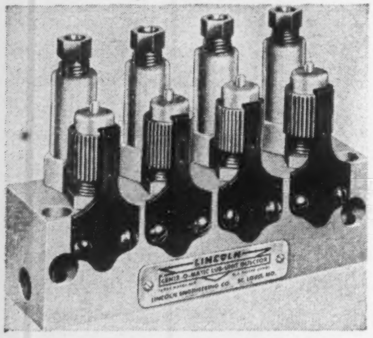


Flat, phenolic-cased capacitors, designed for conditions where space is at a premium, are designed for close stacking and assembly requirements of miniature apparatus. Capacitors with capacities of 0.001 and 0.005-mfd measure 9/16 by 5/16 by 3/32-inch, while units of 0.05-mfd capacity measure 11/16 by 29/64 by 7/32-inch. Working potential of all units is 75 volts dc. Sealed against 80 per cent relative humidity, the capacitors have an operating temperature range of −55 C to +65 C. while lower capacity ratings can be furnished for service to 85 C. Tolerance for 0.05-mfd units is ±30 per cent; for all other units it is +60 per cent. −20 per cent. The 0.001 and 0.005-mfd capacitors are paper-dielectric types impregnated with mineral oil and the 0.01 and 0.05-mfd types are paper-dielectric impregnated with wax. Manufacturer: Tobe Deutschmann Corp., Canton, Mass.

For further information circle MD 19 on Page 243

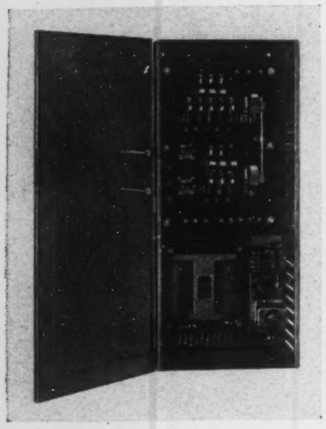
Compact Lubricant Injectors

Small, compact, space-saving units especially designed for use where mounting space is limited, the new type SL-3 lubricant injectors have only two moving parts, the valve stem and piston. These operate in a packing of oil and grease-resisting material which compensates for wear that would otherwise result in leakage. The injectors are available either singly or in manifolds of two, three or four. Base blocks are drilled so that injectors can be mounted in either vertical or horizontal position, and discharge is by positive displacement. Injector block has ⅛-in. IPT female connection at each end while outlet of each unit is ⅛-in. tube. Manufacturer: Lincoln Engineering Co., 5701 Natural Bridge Ave., St. Louis 20.



For further information circle MD 20 on Page 243

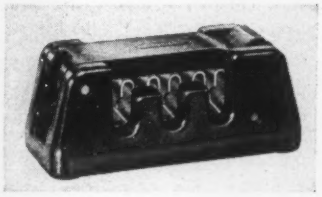
Automatic Motor Starters



Nonreversing autotransformer type of motor starters are designed for use with single-speed two or three-phase squirrel-cage induction motors driving pumps, fans, etc. Units are advantageously used where inrush starting currents must be reduced, or where motor starting torque requires adjustment. The drip-proof enclosed starter is compact and conveniently arranged in three removable sections: Contactor panel, timer panel and multi-tap autotransformer. For ease and simplification of installation, all line-load and control terminals are completely accessible. Adjustable time-limit acceleration, overload protection, mechanical and interlock protection and adjustable taps on the autotransformer are provided on all starters. Suitable for two-wire or three-wire control, Bulletin 4051 alternating-current automatic motor starters are available in standard sizes for use with squirrel-cage induction motors up to and including 100 hp at 550 volts, 60 cycles. Manufacturer: Ward Leonard Electric Co., Mount Vernon, N. Y.

For further information circle MD 21 on Page 243

Space-Saving Terminal Block



Compact, time saving terminal block for battery connection consists of a molded junction box accommodating three terminals in a compact arrangement. Furnished in sizes with cable holes ⅜, 7/16 or ½-in. in diameter, the unit, known as Bus-K-Nect, will carry low-voltage, high-current circuits commonly found on trucks and busses. It is easily installed and facilitates rapid changing of batteries without use of tools. Manufacturer: Scintilla Magneto Div., Bendix Aviation Corp., Sidney, N. Y.

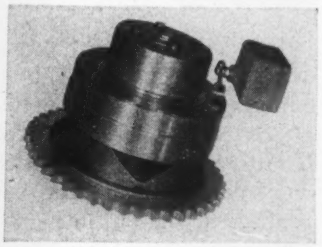
For further information circle MD 22 on Page 243

Attenuators

Voltage attenuator suitable for electronic circuits has a totally shielding housing which is at the same time dust tight. The nonferrous can is provided with an improved dust-cover lock which permits removal with one hand. Cover is also of reduced height, decreasing by 50 per cent the space required for removal. New features include elimination of moisture-absorbing materials, and choice of single or double-hole mounting. Manufacturer: The Daven Co., 191 Central Ave., Newark, N. J.

For further information circle MD 23 on Page 243

Safety Overload Cutout



Overload safety cutout is designed to slip when torque demand reaches excessive values. When an overload occurs, power is cut off and the cutout immediately resets itself and is ready to function again. Available in three models covering a wide torque range, the units are controlled by springs designed to suit the particular application. Size 00 will accommodate working torques from 20 to 150 lb-in.; size 1 is

Johnson Bronze Sleeve Bearings Give You Every Worthwhile Advantage

- **LOW COST**
- **PRECISION**
- **QUIET**
- **LONG LIFE**
- **CORROSION RESISTANT**
- **UNIT CONSTRUCTION**
- **LOAD CARRYING CAPACITY**
- **HIGH RESISTANCE TO SHOCK**
- **LOW COEFFICIENT OF FRICTION**
- **EASY TO INSTALL**
- **CONFORMABILITY**
- **NATION WIDE SERVICE**

SIMPLIFY

and Save

Are you buying more bearing than you need? Are you building sales resistance into your product by making it too complicated? One of the easiest ways to simplify the design and operation of a motive unit . . . without sacrificing performance or efficiency . . . is to install Johnson Sleeve Bearings.

The adoption of Sleeve Bearings brings many worthwhile advantages. It gives the designer more freedom in tolerances. It simplifies installation, also maintenance and replacement. The solid bearing surface provides excellent load carrying capacity. This bearing surface permits a continuous film of lubricant to form between the bearing and shaft . . . preventing wear, eliminating noise and reducing friction to the minimum.

Johnson Sleeve Bearings are more economical too. Their low unit cost provides manufacturers with a much lower cost and a greater profit on each model. They are precision made . . . of highest quality materials. Why not investigate the possibilities of using Johnson Sleeve Bearings in your product? We can give you sound advice and excellent delivery—NOW.

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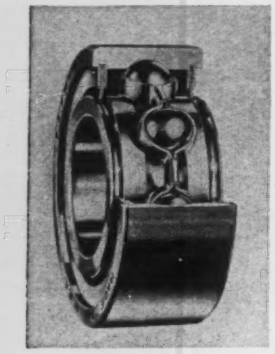
JOHNSON BRONZE
SLEEVE BEARING HEADQUARTERS

designed for torques from 150 to 650 lb-in., and size 2 is suitable for torques ranging from 500 to 2500 lb-in. All three models are designed for speeds up to 1200 rpm. Manufacturer: Anchor Steel and Conveyor Co., 2563 Bellevue Ave., Detroit 7.

For further information circle MD 24 on Page 243

Single-Row Sealed Ball Bearings



Single-row ball bearing line of same width as the standard double-row ball-bearing incorporates Plya-Seals on both sides of bearing for retention of lubricant and exclusion of foreign material. Principal advantage of the new bearing is the fact that it is a self-contained antifriction unit carrying a large sealed-in supply of factory-packed grease ample for years of operation. Use of single row of balls in space normally given to two rows provides for a large supply of grease without total filling thus permitting breathing without leakage. Double row size insures good shaft and bearing support without slippage, while the wide inner-ring face provides pull-off face area over standard shaft-shoulder diameters. The new W-PP line of bearings is being produced in bore sizes from 20 to 70 mm in two series: W204PP to W210PP inclusive and W306PP to W314PP inclusive. Manufacturer: The Fafnir Bearing Co., New Britain, Conn.

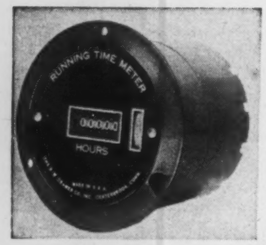
For further information circle MD 25 on Page 243

Aluminum Casters

High-strength aluminum-alloy casters are designed to fill the demand for nonsparking, nondielectric units for use under hazardous conditions. Possibility of sparks, caused by hitting metallic objects, or accumulations of static electricity is thus eliminated. Manufacturer: Market Forge Co., Everett 49, Mass.

For further information circle MD 26 on Page 243

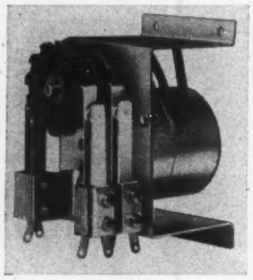
Running-Time Meter



Registering total operating time or idle time of any circuit, machine or system to which connected, the new time totalizer features a counter that can be reset to zero. Typical applications of the meter include operating-time measurement of vacuum tubes, and check of operating hours of equipment. Motor powered, the unit contains a precision-built five-digit revolution-type counter which indicates in tenths up to 10,000 hours and then repeats. Meters are available in three styles. Type E5, furnished in attractive die-cast housing, Type E6 enclosed in metal housing arranged for conduit connection, and Type E7 (illustrated), a 3 3/4-inch diameter instrument enclosed in combination die-cast and plastics housing for flush-panel mounting. It is equipped with knob reset accessible from the front. Operating on rated voltage plus 10 per cent, timers are available to operate on 50 or 60-cycle, 110 or 220-volt power. Manufacturer: R. W. Cramer Co. Inc., Centerbrook, Conn.

For further information circle MD 27 on Page 243

Multi-Circuit Timers



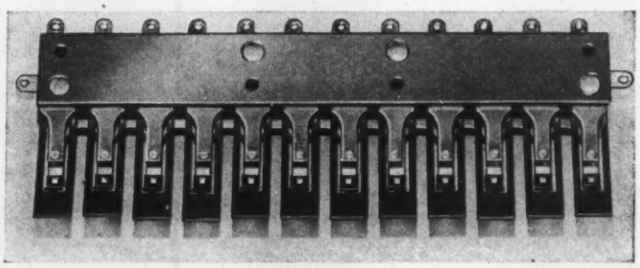
Designed for applications such as automatic vending machines, automatic laundry machines and other types of equipment requiring time and sequence control, Cramer model VF timers are available with up to 6 circuits. Timers measure 2 1/2 by 3 5/8 by 3 5/8 inches high (for the large size) and are equipped with a type SX synchronous motor for ample power and dependability. They are available in a variety of speeds from 1/24-rpm to one rpm. Timers are designed to handle 6, 24, 110 or 220 volts 50 or 60-cycle power and carry 10 amperes across the contacts of a single or double throw switch. Depending on applications, units are available with either slow make or break or snap action. Manufacturer: R. W. Cramer Co. Inc., Centerbrook, Conn.

For further information circle MD 28 on Page 243

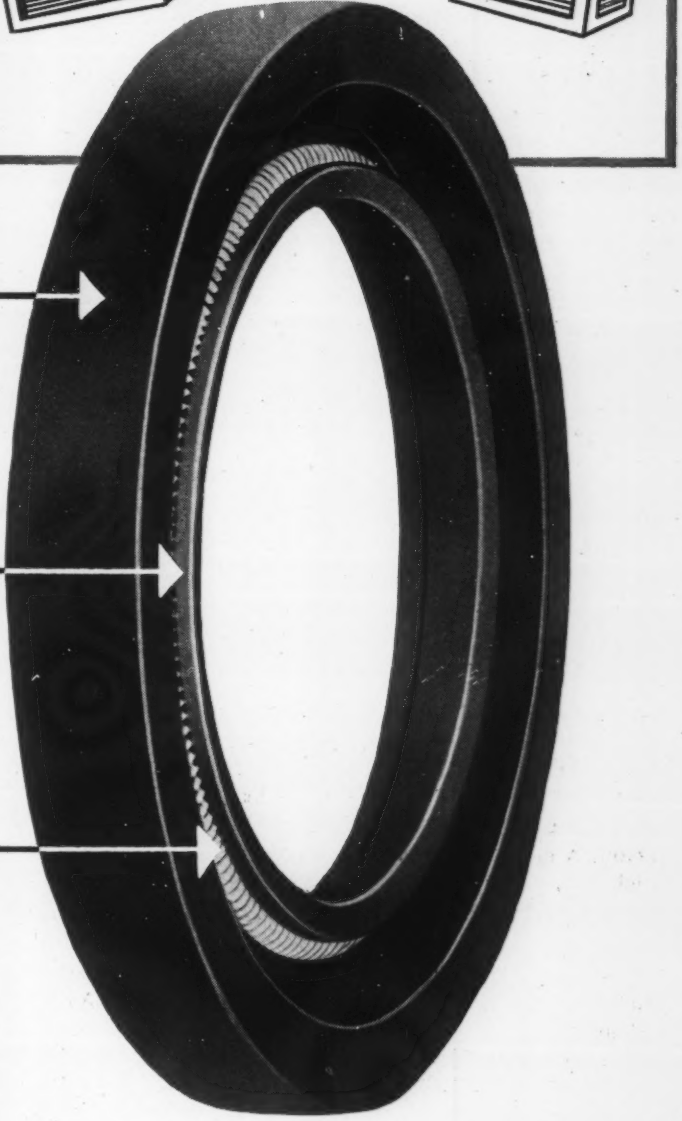
Ganged Limit Switches

Twelve-gang, open-blade snap switch is designed for either cam or plunger operation. Measuring 5⅞ by 2 1/16 by ½-inch, the limit switch is rated at 10 amp, 125 volts ac. The switch requires an operating force of 4½ to 6 oz with a maximum movement of 1/16-inch and an overtravel of 1/16-inch. It is available having a normally-open, normally-closed or double-throw circuit on any pole or combination of poles, and may be had in other multiple arrangements. Manufacturer: The Acro Electric Co., 1311 Superior Ave., Cleveland.

For further information circle MD 29 on Page 243



AN OIL SEAL as Simple as



A

RIGID HEEL

provides a positive press fit in the cavity, assuring a leakproof seal at this point.

B

FLEXIBLE LIP

an integral part of the seal, is available in a variety of designs to meet a wide range of conditions.

C

GARTER SPRING

controls lip pressure to provide most effective sealing and maximum seal life.

- The J-M Clipper Seal has all the virtues of simplicity—plus the practical advantages of superior bearing protection, longer life and ease of installation and removal which only an oil seal of its unique design can provide.

Consisting only of a moulded one-piece body and a garter spring, the Clipper Seal has no metal case. This permits greater bore tolerances. The relatively dense, rigid heel, designed for a press fit in the packing recess, eliminates the need for a cover plate for pressures under 5 psi. The tough, flexible lip is held in light but firm contact with the shaft by the garter spring which causes it to seal with a minimum of friction and wear.

Clipper Seals are recommended for packing against oil, grease, water, air, grit and coolants at temperatures up to 225 F. They are available in sizes from ⅝″ diameter up.

For further details, write Johns-Manville, Box 290, New York 16, N. Y.

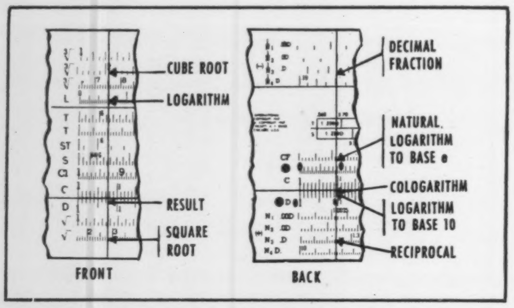
JOHNS-MANVILLE JM PRODUCTS

Johns-Manville **PACKINGS & GASKETS**

engineering dept equipment

To obtain additional information on these new developments see Page 243

Deci Log Log Slide Rule



Simplified arrangement of new slide rule facilitates rapid computation. Scales on front of rule are so arranged that only one setting of the hairline is required to determine square root, cube root and logarithm. Log-log scale on back of rule is expanded for accuracy and arranged to give five readings with any setting of the hairline. These readings are: Decimal fractions to four and five places, their reciprocals to four and five places, logarithms, cologarithms and natural logarithms. The log-log scales read from one-ten-billionth to ten billion and give decimal point location. A simple legend tells which scale to read when raising to powers. The rule is magnesium alloy with plastics surfaces bearing permanent washable scales. Measuring 12⅛ by 2⅛ by 3/16-inches, it comes complete with carrying case and instruction manual. Manufacturer: Pickett & Eckel, Inc., 5 S. Wabash Ave., Chicago 3.

For further information circle MD 30 on Page 243

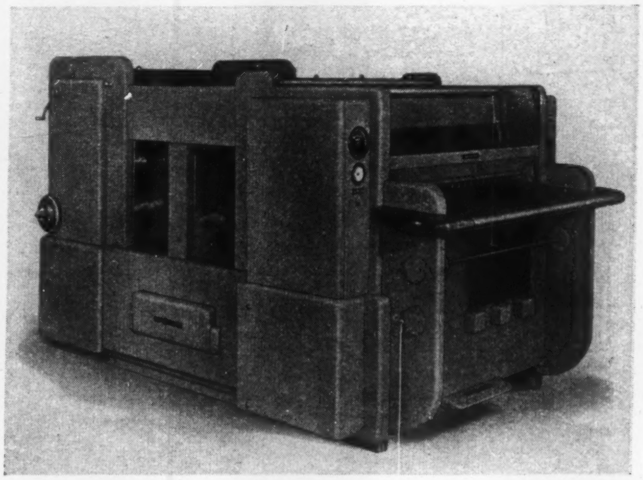
Power Supply

Power supply will provide voltage variable from 0 to 20 amperes from a 115 or 230-volt, 60-cycle supply. The unit functions by the use of two variable transformers which are used separately for current or voltage taps. For metering purposes, a triple-range voltmeter and a double-range ammeter are supplied. These meters are accurate to one per cent. Output voltage ranges are 0-30, 0-150, and 0-300 volts while current ranges are 0-5 to 0-20 amperes. A circuit-breaker provides instrument protection. Manufacturer: Superior Electric Co., 280 Church St., Bristol, Conn.

For further information circle MD 31 on Page 243

Automatic Blueprinting Machine

Continuous blueprinting machine designed for the high-speed production of blueprints, whiteprints, vandykes and blueline prints, automatically exposes, treats, washes and dries prints. The machine, known as the model M4, uses a 12-inch diameter Pyrex glass cylinder which revolves with the work thus assuring slip-free and static-free contact between tracing and print paper. Light is provided by a 75 or 90-watt quartz lamp. After prints are exposed they are developed and washed in a series of spray and submerged baths and dried by passing around a series of electrically-heated aluminum drying drums. Machine is sturdily constructed with cast-aluminum frames and precision ball bearings, and is finished in a grey wrinkle lacquer. Overall dimensions are 126 inches long and 70 inches wide for the 42-inch machine and 82 inches wide for the 54-inch machine. Manufacturer: Paragon-Revolute Corp., 77 South Ave., Rochester 4, N. Y.

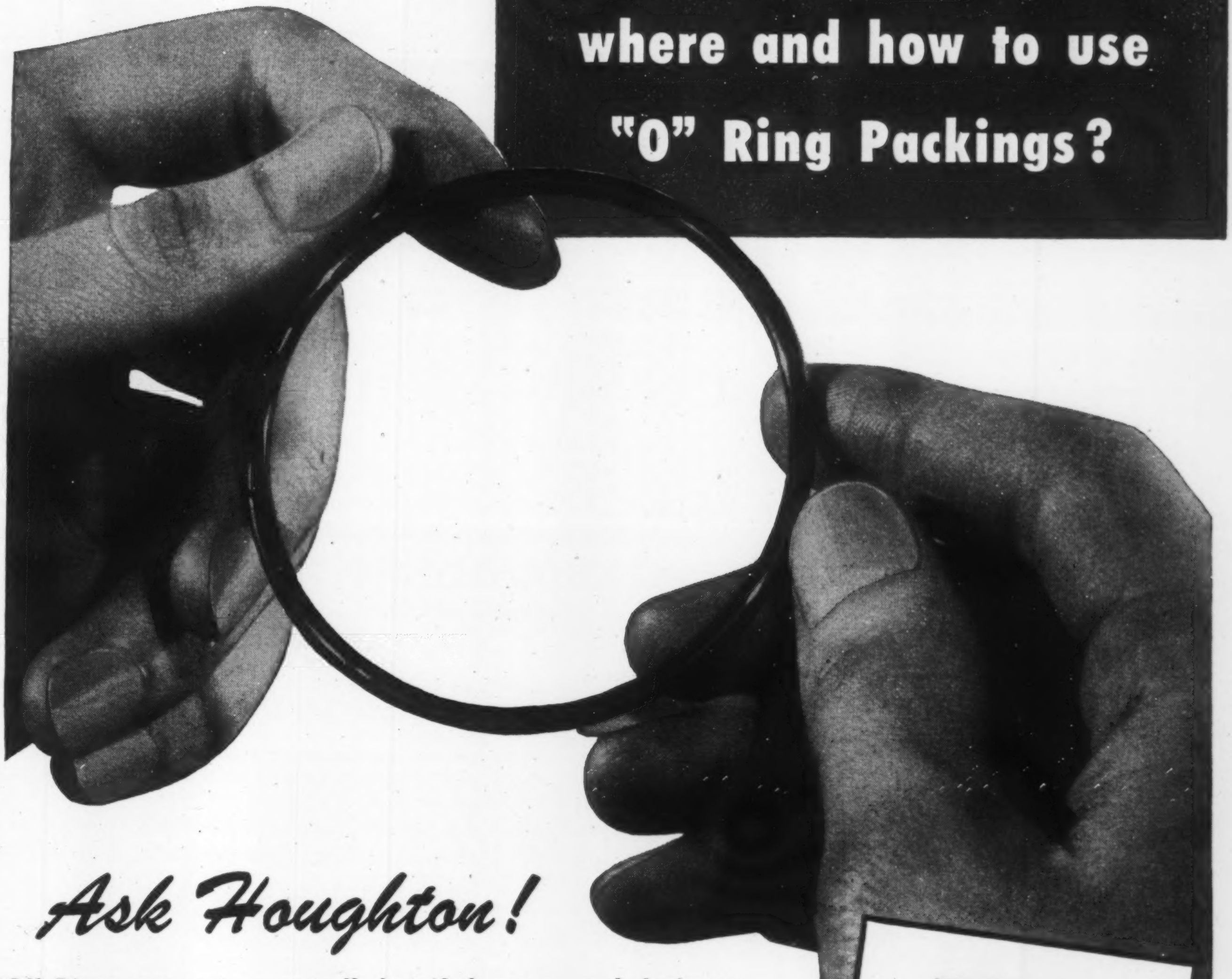


For further information circle MD 32 on Page 243

Electron-Tube Wall Chart

Basic information on operation, types and applications of electron tubes covering both vacuum and gas-filled types is presented in a new wall chart now available. Printed in eight colors on heavy linen paper

Want the facts about where and how to use "O" Ring Packings?



Ask Houghton!

"O" Rings are not a cure-all, but if the user and designer observe their limitations, they can be a simple answer to many packing problems.

They should not be used at high pressures; 1500 PSI is the limit unless back-up washers are used to prevent extrusion. They should be purchased from a licensed source, as their installation (not their design) is patented.

"O" Rings are primarily used for reciprocating motion. Their sizes have recently been standardized, as covered in the new Vix-Syn Packing Handbook just published.

As packing pioneers, Houghton can from experience save many headaches when you are planning seals for a hydraulic mechanism. This service ranks in importance with the packings themselves; it's yours if you write E. F. Houghton & Co., 303 W. Lehigh Ave., Philadelphia 33, Pa.

VIM Leather Back-up Washers are recommended for use with "O" Rings when pressures exceed 1500 PSI. They prevent the rings from extruding into the clearance, thus extending packing life. Ask the Houghton Man for full factual details.

HOUGHTON'S

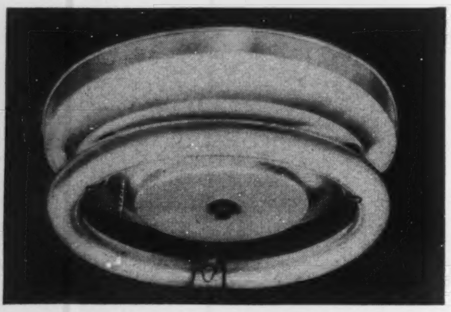
VIM LEATHER AND VIX-SYN PACKINGS

the chart is reinforced by metal strips and is hinged for hanging. It shows how the electron is freed in electron tubes, basic structural types of tubes and primary functions. Manufacturer: Westinghouse Electric Corp., 306 Fourth Ave., Pittsburgh 30.

For further information circle MD 33 on Page 243

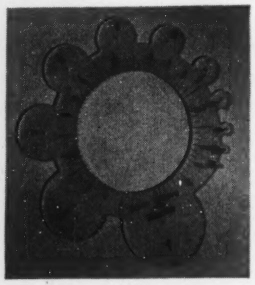
Circular Fluorescent Lamp

Circular design of new fluorescent lamp greatly reduces shadows, making lamp particularly suitable for drafting room use. Unit is a 32-watt, 12-inch diameter lamp with heavy white-enamel base. Operation is on 110-volt current. Manufacturer: Homecraft Electronic Products, 1208 South Kedzie Ave., Chicago 23.



For further information circle MD 34 on Page 243

Radius Guide for Draftsmen

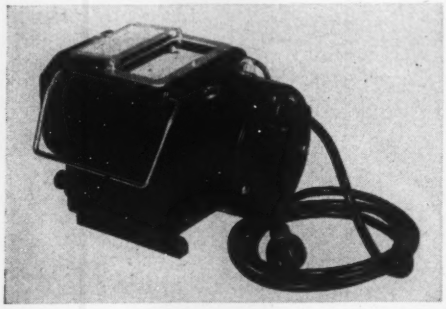


Transparent - plastics radius guide for radii from 1/16 to ¾-inch accurately locates the correct center of circles. Instrument, known as the No. 75, eliminates the time-consuming method of finding the correct center with a compass by the trial and error method. Made of transparent plastics 0.030-inch thick, guide has all edges clean cut and smooth, and calibrations and numerals are imprinted. Diameter of the instrument is 4½ inches. Manufacturer: Rapidesign, Inc., P. O. Box 592, Glendale, Calif.

For further information circle MD 35 on Page 243

Insulation Tester

Line-voltage-powered insulation tester is latest addition to the Megger line. Instrument needs only to be plugged in to 115-volt circuit for operation, requires no cranking as do other models. It is thus recommended for applications where a large number of tests are to be made, or where an individual test is continued over a long period of time. This rectifier-operated instrument is a modification of the Megger line of testers in that the hand generator is replaced by a power pack consisting of a constant-potential step-up transformer and selenium rectifier, giving a constant d-c test voltage. The ohmmeter covers a wide range and is independent of applied voltage. Four models are available with ratings from 0-500 megohms at 500 volts to 2000 megohms at 1000 volts. Manufacturer: James G. Biddle Co., 1316 Arch St., Philadelphia 7.



For further information circle MD 36 on Page 243

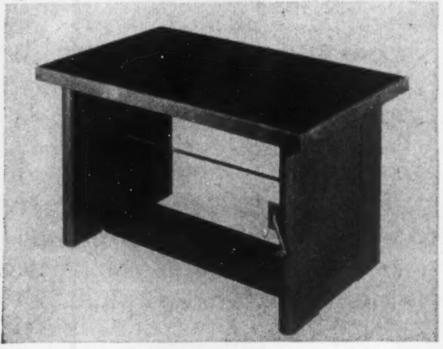
Basswood Drawing Boards

Moisture-sealed line of basswood drawing boards is again available. The No. 8080 boards are manufactured in sizes from 12 by 17 inches to 31 by 42 inches. Sealing process is said to reduce wood warpage to a minimum. Manufacturer: Engineering Mfg. Co., Sheboygan, Wis.

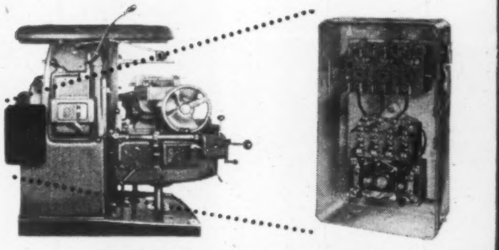
For further information circle MD 37 on Page 243

Adjustable Work Table

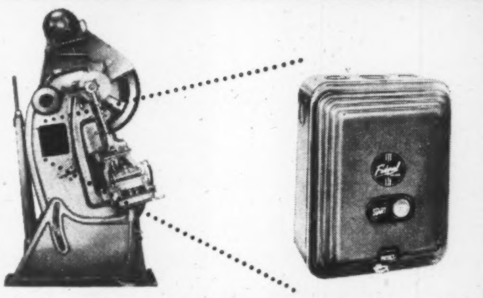
Adjustable-type work table has hand crank for raising or lowering top within the range 26½ to 37-inches from the floor. Sturdily constructed of heavy duty plywood with 20 by 48-inch tempered Masonite top, the new table will hold a load of 300 pounds. Mounted on gliders, the table is said to facilitate efficient work, being immediately adjustable to the position most comfortable for the user. Manufacturer: Haskell Mfg. Co., Dept. MD, 206 Penn Ave., Pittsburgh 21.



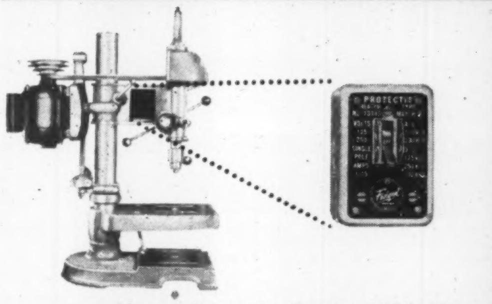
For further information circle MD 38 on Page 243



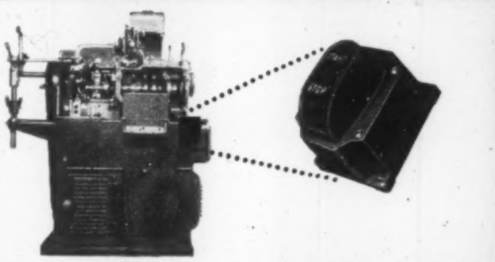
Combination Disconnect Switch and Starter



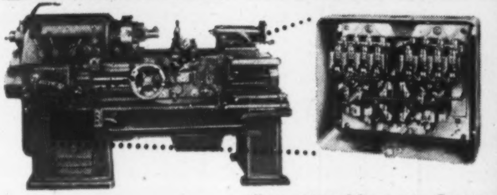
Magnetic Across-the-Line Starter



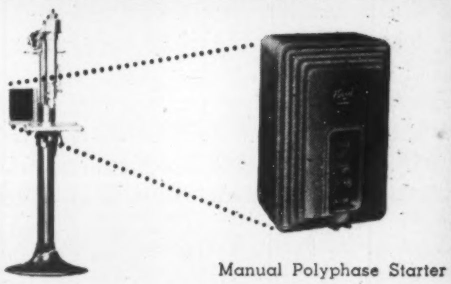
Manual Starter for Fractional H.P. Motors



Oil Tight Control Station



Reversing Magnetic Starter



Manual Polyphase Starter

"Take it from me-

a machine tool is only as efficient as its motor control!"

[illegible]

Federal NOARK

MOTOR STARTERS

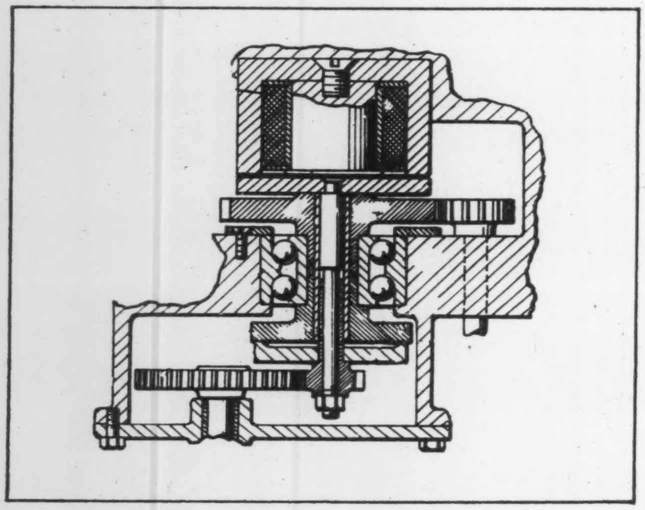
Federal Electric Products Company, Manufacturers of a Complete Line of Electrical Products including Motor Controls • Safety Switches • Service Equipment • Circuit Breakers • Panelboards • Switchboards • Bus Duct

Executive Offices: 50 Paris Street, Newark 5, N. J. • Plants: Hartford, Conn. Newark, N.J. St. Louis, Mo. L.I.C., N.Y.

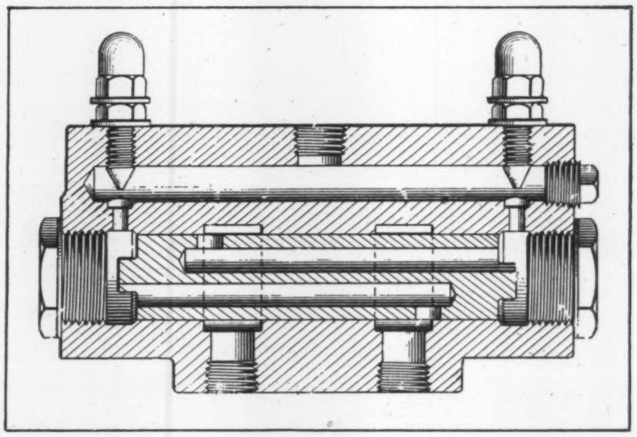
Noteworthy Patents

ACCURATE REGULATION of reciprocation speeds as well as gradual deceleration and smooth reversal is achieved with a new hydraulic speed-control valve for cylinder-driven machine units covered in patent 2,417,583. Assigned to the Vinco Corp. by R. D. Bennett, the valve is particularly adapted to the control of such high-precision machines as gear grinders where working tolerances are extremely small. Control of cylinder speed is by means of an eccentric which sets the position of the throttle plunger. Actuated from a cam on the driven member, a table in the case of a grinder, the throttle decreases the speed to stop position and on reversal of motion accelerates gradually up to preset traverse speed.

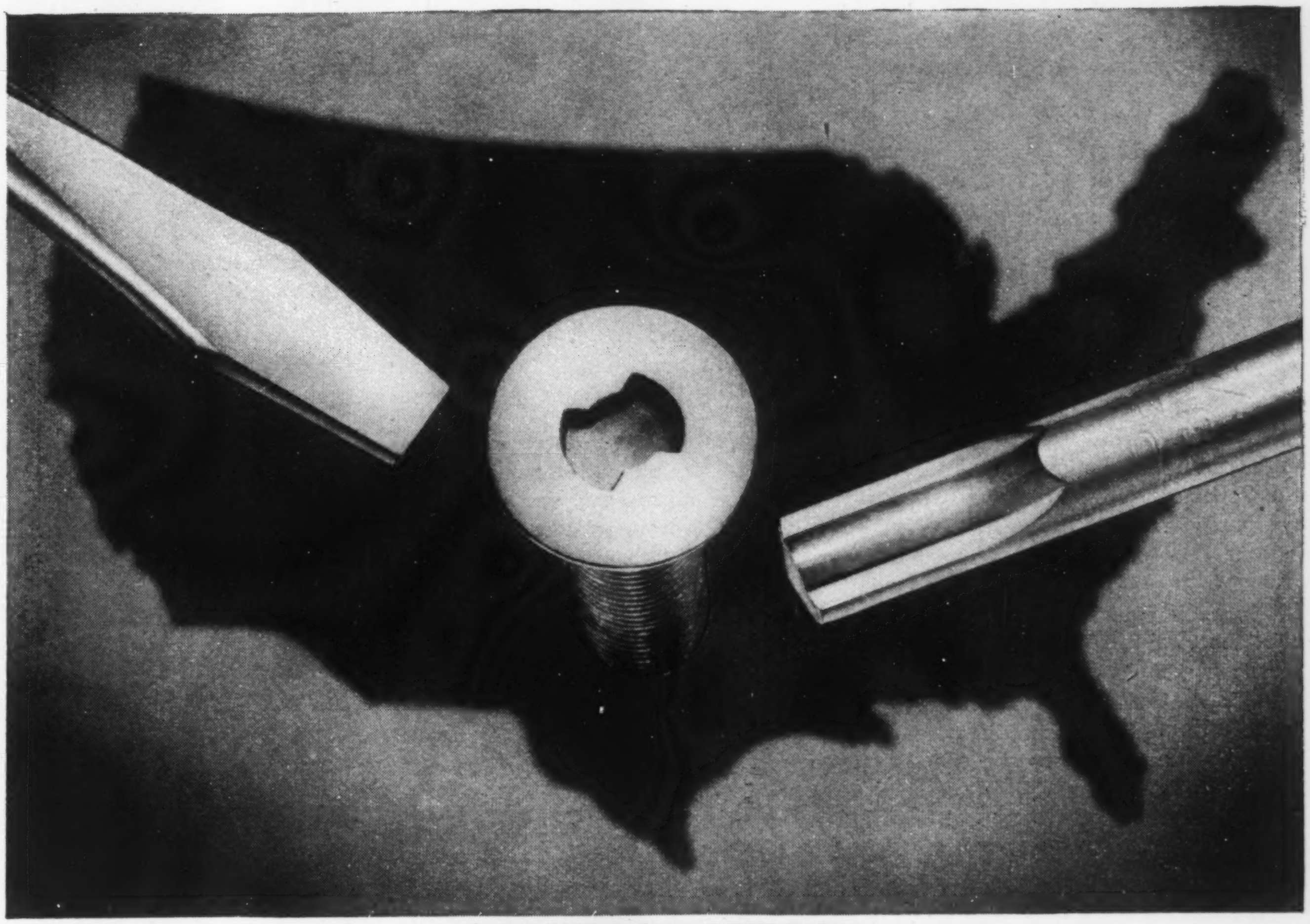
TORQUE CAPACITY of the friction clutch covered in patent 2,418,466 is substantially unaffected by any lubricant which may work onto its gripping surfaces. Utilizing electromagnetic actuation for control, actual contact between the armature and the electromagnet is prevented in operation to avoid wear. Clutch faces are of hardened steel for long life and design of the gripping face is such that a clutching force of 230 psi of area creates a gripping coefficient when working in a lubricated gearbox approximating very closely that of the surfaces when dry. Actual figures on a clutch so constructed show a torque of 5 pound-inches with no slippage as compared to one of 5 5/16 pound inches dry. Patent assigned to Woodward Governor Co. by G. F. Drake.



IDENTICAL SPEED RATES despite differences in load on a pair of hydraulic hoists or rams is assured by an unusually simple equalizing valve assigned to Hydraulic Control Engineering Co. by William T. Stephens. Described in patent 2,423,264, the important feature of the valve comprises a floating piston for controlling the fluid passages in accordance with the pressures exerted on opposite ends of the piston. Conversely, the piston controls the quantity of fluid discharged from the hoist rams by the same means, pressure exerted by each ram on the ends of the piston balancing the port openings to allow equal volume discharge regardless of pressure.



WEAR AND VIBRATION normally incident to the operation of a winch or like mechanism are eliminated by a novel friction-responsive pawl control covered in patent 2,414,960 assigned to David Round & Son by Charles C. Martin. Providing substantially noiseless and automatic operation, the unit employs a friction-responsive wire loop, actuated by movement of the winch, to lift the pawl when operation is in a hoisting direction and release the pawl to normal engagement with the ratchet wheel when operating direction is reversed.



CLUTCH HEAD

"America's Most Modern Screw"

A distinction won by proved performance on power assembly lines... where the records of users credit the exclusive features of CLUTCH HEAD Screws with 15% to 50% production increases.

Higher Visibility of the roomy Clutch recess inspires operator confidence to check out slow-down hesitation.

No Chewed-up Heads. That Center Pivot Column on the Type "A" Bit prevents driver canting and insures automatic straight driving.

Safe Non-tapered Drive eliminates need for end pressure to combat skid hazard "ride-out" as set up by tapered driving.

Slippage Goes to Zero with CLUTCH HEAD's all-square driving engagement. The straight sides of the Bit match straight walls of the Clutch recess, making the drive-home almost effortless.

A Fatigue Factor Disposed Of. Absence of end pressure means safer, faster, easier driving... checking out end-of-the-shift "lag" for a stepped-up driving tempo.

Lock-on Breaks "Bottlenecks". Only CLUTCH HEAD provides this feature for easy one-handed reaching to inner spots.

Solves Field Service "Headaches" Too. With the Type "A" Hand Driver, service men find it easy to withdraw screws undamaged and held safely on the bit for re-use.

Fractional Tool Cost. This rugged Type "A" Assembly Bit holds the record of 214,000 screws driven in continuous operation without reconditioning. A 60-second on-the-spot operation restores it to original efficiency . . . *repeatedly*.

Screwdriver Control. This is the only modern screw basically designed for operation with a common screwdriver . . . a boon to emergency service.

You are invited to make your own appraisal of these exclusive CLUTCH HEAD *features.*

CLUTCH HEAD SCREWS

Send for package assortment of screws, sample Type "A" Bit, and illustrated Brochure.

UNITED SCREW AND BOLT CORPORATION

CLEVELAND 2 CHICAGO 8 NEW YORK 7

MEN...of...machines

John K. Northrop

JOHN K. NORTHROP, president of Northrop Aircraft Inc., received the highest aviation honor of The American Society of Mechanical Engineers—the Spirit of St. Louis Medal—at its recent semiannual meeting for his development of the "Flying Wing" and other contributions to aeronautical science. The presentation was made in recognition of "his originality and vision in the engineering of military and commercial airplanes, and particularly for his development of a successful flying wing." Mr. Northrop's contributions to aeronautics are many, and a number of his early design methods and details are still in general use. He played a major part in development of craft such as the Vega, Northrop Alpha, Delta and Gamma series, the A-17 attack planes, early Navy dive bombers and the Flying Wing. Born in New Jersey in 1895, he moved with his family to California where he graduated from high school. He then turned to following his natural bent for applied mechanics. After serving in World War I, he joined Douglas Aircraft. Later he formed the Lockheed Aircraft, and in 1928, with W. K. Jay, Avion Corp. was founded. This corporation built and flight tested a flying wing which made many flights in 1929 and 1930 and furnished valuable aerodynamic and structural data. In 1930 the firm became a unit of United Aircraft. Two years later the Northrop Corp. was formed. The present Northrop Aircraft Corp. was founded in 1939 with Mr. Northrop as its president and head of engineering and research.

C. W. LaPierre

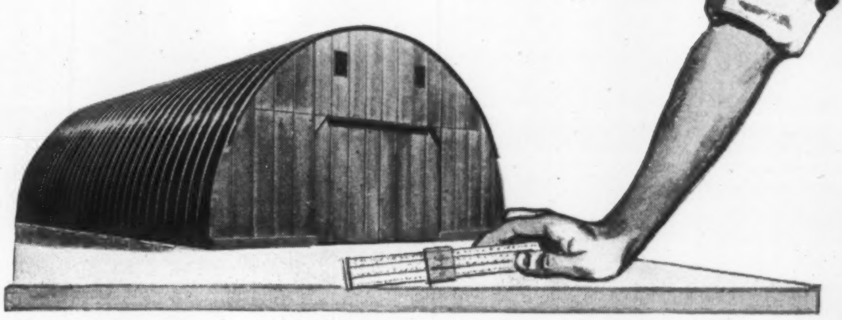
C. W. LAPIERRE in his new post as vice president in charge of engineering, American Machine & Foundry Co. will be responsible for the engineering policies of all divisions of the company. Well known as an electrical engineering expert, especially in the electro-mechanical field to which he has made many contributions, Mr. LaPierre formerly had been manager of General Electric's electro-mechanical division of the general engineering and consulting laboratory. In this capacity he directed the development of a wide variety of mechanical and electrical devices which have been used in the electrical, textile and other industries. Mr. LaPierre has had broad experience in the fields of electronics, optics, heat transfer, noise and vibration, and recently was active in the development of an atomic power plant. In 1937 he received the Charles A. Coffin award for outstanding accomplishment. A native of Jackson, Mo., he was a member of the class of 1925 at the University of Missouri's engineering school.

D. Roy Shoults

D. ROY SHOULTS, vice president in charge of engineering of Bell Aircraft Corp. since the fall of 1945, has taken over new duties as chief engineer of The Glenn L. Martin Co. For almost twenty years prior to joining Bell Aircraft, Mr. Shoults had been with General Electric. His last position with G E had been that of engineer of the Aviation Division with application engineering responsibility for the company's aircraft apparatus products.

Born in 1903 in Ohio, Mr. Shoults was graduated from the University of Idaho in 1925 with a degree in electrical engineer-

WHAT HAS MY PRODUCT IN COMMON WITH ALUMINUM BUILDINGS?

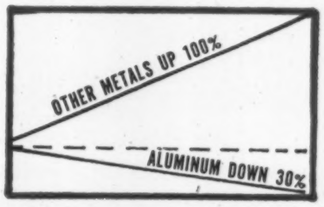


PLENTY, if you're looking for proof how a product, in a highly competitive market, can be given the advantages of aluminum at little or no increase in cost.

This new prefabricated farm and utility building is all-aluminum inside and out, never requires paint, is fire and vermin proof. The common assumption would be that its price is "out of this world" compared to steel. Actually, there's little or no difference in the final erected cost.

And that's where manufacturers are guilty of a common error in evaluating aluminum. They forget that pound for pound aluminum gives *three times* the working area of steel, brass or copper—often overlook the economies of handling and assembling this lightweight material, which, in the case of this building, cut erection costs in half. And, even more important, they fail to take into consideration that aluminum is available for immediate delivery at the lowest prices in history.

The true cost of aluminum doesn't stop with a price per pound quotation. Consideration of all the factors may disclose that you can't afford *not* to use this modern metal. The services of a Reynolds technician to aid you in this study are yours for the asking. Write Reynolds Metals Company, 2521 South Third Street, Louisville 1, Kentucky.



The price of aluminum has been reduced 30% since Reynolds became a primary producer in 1939.

REYNOLDS METALS

REYNOLDS
THE GREAT NEW SOURCE OF **ALUMINUM**

INGOT • SHEET • SHAPES • WIRE • ROD • BAR • TUBING • PARTS • FORGINGS • [illegible] ing. Upon graduation, he took General Electric's test course and the advanced engineering course. For the next fifteen years he handled industrial application engineering projects in widely diverse fields such as lumber mills, printing mills, paper mills, etc. His special work included that of synchronous motors, photoelectric control systems and special electronic regulators. In 1940 he was transferred to the organization of application engineering for the turbosupercharger and other aviation equipment branches. Twenty patents, issued to Mr. Shoults, were assigned to General Electric. At Bell Aircraft, he was closely involved in high-speed airplane and helicopter engineering, as well as other advanced engineering projects. Mr. Shoults also had a leading civilian role in the United States Government's first exploratory survey of British jet-engine developments and had important engineering responsibilities in co-ordinating the first jet engine program in this country.

◆

Dr. Arpad L. Nadai has been awarded the Worcester Reed Warner Medal, which is given by the American Society of Mechanical Engineers honoring noteworthy contributions to the permanent literature of engineering. Dr. Nadai is consulting engineer of the Westinghouse Research Laboratories.

◆

Morrough P. O'Brien, former dean of engineering of the University of California, has joined the engineering staff of Air Reduction Co. He will be in charge of general and process engineering, and of liquefaction research. Dr. Floyd J. Metzger, whom Mr. O'Brien succeeds, has resigned as vice president in charge of liquefaction research to engage in private practice as consultant.

◆

Loren E. Boysel has been named body engineer at Willys-Overland Motors, replacing C. E. Schutte, resigned. Mr. Boysel formerly had been associated with engineering and quality control for the Fisher Body. He also had been active in aviation engineering during the war.

◆

L. A. Welch has been appointed executive vice president of R. G. LeTourneau Inc., Peoria, Ill. Mr. Welch brings with him a broad background of experience obtained in posts he filled, such as deputy director of production in the WPB, regional director of the WPB in Detroit, and president of the Avery Farm Machinery Co.

◆

A. C. Bloomer, formerly chief draftsman of Universal Corp., Dallas, Tex., has been appointed chief engineer.

◆

Thomas A. Bragdon, until recently assistant production engineer for W. L. Maxson Corp., has been named structural design engineer for Chance Vought Aircraft, Division of United Aircraft Corp., Stratford, Conn.

◆

Richard L. Zenker, who served for three years as a design and development engineer for the Army Air Corps, has been named to the staff of Battelle Institute where he will be engaged in research on combustion processes.

◆

Jerold L. Welch, who had been assistant chief engineer with the Cleveland Hobbing Machine Co., Euclid, O., has joined the Lewis Welding & Engineering Co., Bedford, O.

◆

A. W. Laird has been promoted from director of engineering, Hydraulic Division of the New York Air Brake Co., Watertown, N. Y., to assistant to the president of the same company, with office at 420 Lexington Ave., New York City.

◆

A. G. Laas, formerly assistant executive engineer, has been appointed executive engineer at the Studebaker Corp., South Bend. S. A. Jeffries, chief truck engineer, is the new executive truck engineer, and R. E. Mackenzie, formerly special engineer, is chief truck engineer. The top engineering plan board of the company, headed by R. E. Cole, vice president in charge of engineering, will include E. J. Hardig, chief chassis engineer; S. W. Sparrow, director of research; and H. E. Churchill, chief research engineer.

◆

Joseph P. Benjamin, previously chief draftsman for Ellinwood Industries, has become design engineer for C. F. Braun & Co., Alhambra, Calif.

◆

H. L. Newell, formerly president of Waring Products Corp., has been appointed manager of the central engineering department of American Machine & Foundry Co., with headquarters in Brooklyn. From 1937 to 1945 he was head of the advanced engineering section of the appliance and merchandising division of General Electric at Bridgeport.

◆

C. D. Clawson of Ferro Enamel Corp., has been elected president of the Porcelain Enamel Institute at its Sixteenth Annual Meeting, held recently.

◆

Dr. A. H. Stuart, who has been director of research of Schieffelin & Co. for many years, as director of research for Charles Bruning Co. Inc., will be in charge of the company's long-range research program designed to improve and extend its present line.

◆

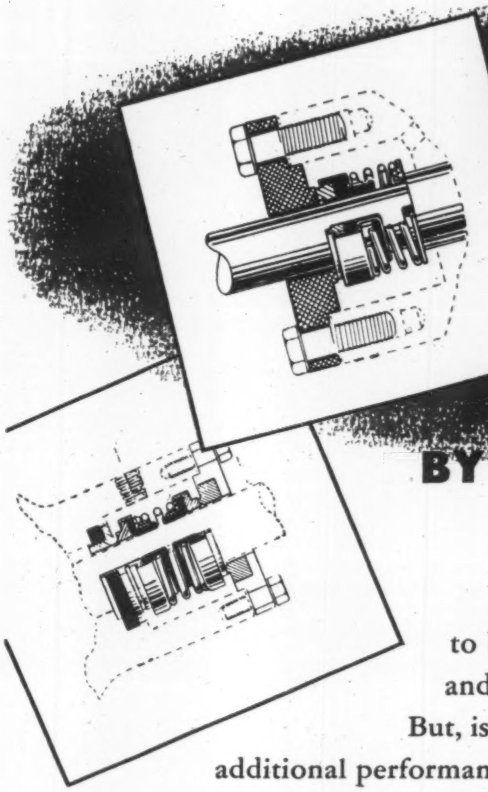
Prof. R. S. Green of the department of industrial engineering, Ohio State University, has been appointed editor-in-chief of the Lincoln Foundation's new book, "Design for Welding", which will include a survey of the latest developments in welding.

◆

William D. Owsley has been named technical advisor of Halliburton Oil Well Cementing Co. Formerly chief engineer of the company, Mr. Owsley will devote full time to field engineering requirements.

◆

Charles R. Hook, president of American Rolling Mill Co., has received the medal for the advancement of research, awarded by the American Society for Metals.

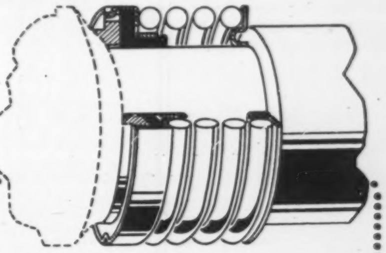


YOUR PRODUCT *Performance* MAY BE HANDICAPPED BY INEFFICIENT SHAFT SEALING

Offhand your present shaft sealing method may *appear* to be satisfactory. Even though considerable maintenance and periodic replacement is required, you are "getting by." But, is just getting by good enough? Have you considered the additional performance features that might be possible by using a Rotary Seal?

Often, a study of a product reveals that important new operating advantages, including long, trouble-free service and long-term economy, could be gained through the use of a more efficient seal. The apparent economy achieved in the use of a low-inital-cost, ordinary sealing method is found in many cases to be a disguised liability. Constant maintenance, inefficient performance and limited operating features prove costly deficiencies.

No matter what method you are now using, you may be surprised at the advantages that reliable Rotary Seals can give your product. Just send in drawings of shaft assemblies and full information on operating and service conditions of your product. We shall be glad to submit a proposal.



Know why a Rotary Seal is best?

The entire Seal Assembly rotates with the shaft. A running seal joint is formed by continuous, intimate contact between the rotating seal face and the mating, fixed, stationary seal seat. This contact is maintained by the pressure exerted by the coil spring. The flexible, elastic driving member, fitting frictionally tight around the shaft, acts to prevent leakage at that point. The seal face can adjust its running plane—either angularly or laterally — to compensate for shaft vibration, deflection or slight misalignment. Simplicity in design and function are basic reasons for the efficiency and practicability of the Rotary Seal principle.

Send for Booklet "Sealing with Certainty on Rotating Shafts" completely describing and illustrating Rotary Seals.

THE ROTARY SEAL COMPANY
mechanical seals for rotating shafts

ROTARY SEAL COMPANY, 2022 N. Larrabee Street, Chicago 14, Ill.

Solution of Equations

(*Continued from Page* 142)

vantageous to depress the original equation by the first roots found. Here, for example, substitution of $x = 2$ in the original equation would have made the quadratic formula readily applicable for the determination of the remaining two roots.

EXAMPLE 2—REPEATED REAL ROOTS: The possibility of applying this method to an equation with real roots, one of which is repeated, now will be investigated. The Encke roots are taken to be a, b, b, c, etc., where $|a| > |b| > |c|$ etc. After forming the general equation from these roots, transforming this equation to one whose Encke roots are the mth power of the original ones, and then retaining only the dominant terms for m sufficiently large, there results the equation

$$x^n+a^m x^{n-1}+2a^m b^m x^{n-2}+a^m b^{2m} x^{n-3}+\ldots=0 \qquad (9)$$

The observation that the coefficient of x^{n-3} term is not $a^m b^m$ but $2a^m b^m$ makes it possible to detect the repeated root. In actual computations this condition is recognized when a coefficient in the new equation is just half the square of the corresponding coefficient in the previous equation. The double product is also found to persist, that is, it does not approach the vanishing point. The computations need be carried no further in the table unless to eliminate other decreasing double products. Comparing Equations 8 and 9,

$$B_1=a^m$$

$$B_2=2a^m b^m=2B_1 b^m$$

$$B_3=a^m b^{2m}=B_1 b^{2m}$$

The repeated root therefore may be determined after dividing the coefficient following the irregular term by the coefficient of the term preceding the irregular term. Hence in this case $b^{2m} = B_3/B_1$. Alternatively, it may be found by dividing the coefficient of the irregular term by twice that of the preceding term or, in this case, $b^m = B_2/2B_1$. The remaining roots are determined in the usual manner.

As an example of repeated real roots, it is required to solve the equation:

$$x^4-4.87x^3+2.36x^2+9.38x+1.15=0$$

Construction of TABLE II is carried out in the same manner as for the previous example. Negligible double products are indicated by dots. The behavior of the x^3 coefficient discloses the presence of a repeated root, 13,200 being half the square of 163, while the double product does not become negligible. The repeated root, a, therefore is found by dividing the coefficient of x^2 by the coefficient of x^4 giving $a^{2m} = B_2$. Alternatively, it is given by $a^m = B_1/2$. The remaining roots are found as before, that is, $b^m = B_3/B_2$ and $c^m = B_4/B_3$. From the final line of the table, $B_1 = 13{,}200$, $B_2 = 42.8 \times 10^6$, $B_3 = 43.0 \times 10^6$, and $B_4 = 3.03$, therefore

$$\log a^2=\frac{\log\,(4.28\times10^7)}{8}=0.955 \qquad \therefore\ [a]=3.00$$

$$\log\,b=\frac{\log 4.30-\log 4.28}{8}=0 \qquad \therefore\ [b]=1.00$$

$$\log\,c=\frac{\log 3.03-\log\,(4.3\times10^7)}{8}=-0.894 \qquad \therefore\ [c]=0.128$$

The roots with proper signs affixed are: $+3.00$, $+3.00$, -1.00, -0.128.

EXAMPLE 3—COMPLEX ROOTS: The last case to be considered is that of one pair of conjugate complex roots occurring along with distinct real roots. Let the theoretical equation be of fourth degree with Encke roots a, b, $c + jd$, and $c - jd$. These roots can also be written as a, b, $re^{+j\theta}$, and $re^{-j\theta}$, where $c = r \cos \theta$ and $d = r \sin \theta$. Take $|a| > |r| > |b|$, then

$$(x+a^m)(x+r^m e^{+jm\theta})(x+re^{-jm\theta})(x+b^m)=0 \qquad (10)$$

represents the equation whose roots are the mth power of the given roots. If for m large all but the dominant terms are discarded, multiplication results in

$$x^4+a^m x^3+2a^m r^m(\cos m\theta)x^2+a^m r^{2m} x+a^m b^m r^{2m}=0 \qquad (11)$$

where $e^{+mj\theta} + e^{-mj\theta} = 2\cos m\theta$. If Equation 11 were

TABLE III

m	Coefficient of					
	x^5	x^4	x^3	x^2	x^1	x^0
1	1.00	5.50	1.00	—1.00	1.50	—1.00
	1.00	30.2 —2.0	1.00 11.0 3.00	1.00 —3.00 —11.0	2.25 —2.00	1.00
2	1.00	28.2	15.0	—13.0	0.25	1.00
	1.00	795 —30	225 733 1	169 —8 56	0.063 26.0	1.00
4	1.00	765	959	217	26.1	1.00
	1.00	58.5×10^4 -0.2×10^4	92.0×10^4 -33.2×10^4	4.70×10^4 -5.00×10^4	679 —434	1.00
8	1.00	58.3×10^4	58.8×10^4	-0.3×10^4	245	1.00
	1.00	34.0×10^{10}	34.6×10^{10} 0.3×10^{10}	9.0×10^6 -288.0×10^6	60000 6000	1.00
16	1.00	34.0×10^{10}	34.9×10^{10}	-279.0×10^6	66000	1.00
	1.00	11.6×10^{22}	12.2×10^{22}	7.80×10^{16} -4.60×10^{16}	43.5×10^8 5.6×10^8	1.00
32	1.00	11.6×10^{22}	12.2×10^{22}	3.20×10^{16}	49.1×10^8	1.00

They profit 4 ways with magnesium warp beams

EASIER HANDLING

MORE ECONOMICAL SHIPPING

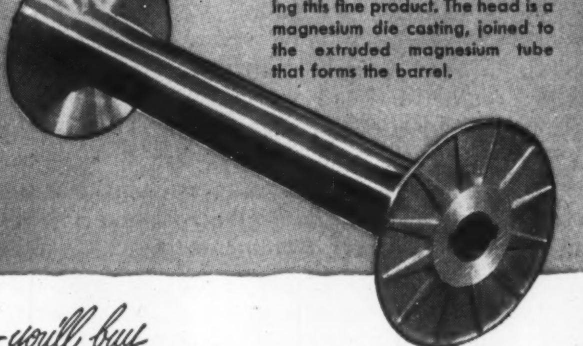
SPEEDIER WARPING

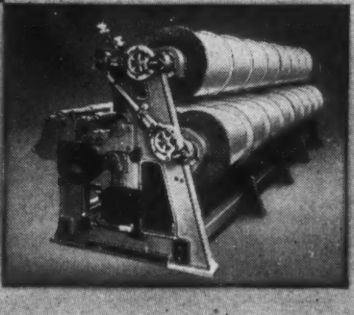
SMOOTHER KNITTING

PROGRESSIVE mill operators are cutting costs—improving quality, too—with these better warp beams . . . made of *magnesium metal!* This unique material gives them lightness, strength, rigidity, balance, and dimensional accuracy. Textile machine manufacturers are using strong, lightweight magnesium for more and more parts to cut inertia and improve machine operation.

PRECISION MADE

Magnesium lends itself well to the precise methods used in producing this fine product. The head is a magnesium die casting, joined to the extruded magnesium tube that forms the barrel.





FOR PRECISION WORK

Added smoothness is achieved in tricot knitting machines through the use of magnesium warp beams. Despite high humidity and varying operating conditions, magnesium beams retain their surface and dimensional stability.

-you'll buy Magnesium Lightness too!

DOWMETAL

AS AMERICA'S pioneer magnesium producer, Dow supplies machine manufacturers in many fields with magnesium. Dow's continuous research and development program plays a vital part in the growing application of magnesium to textile equipment.

DOW

MAGNESIUM DIVISION • THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

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What can be done with COLD FORGING and supplemental operations?

Ask MILFORD!

EXAMPLE ▶ This actually small metal part was formerly screw machined.

MILFORD COLD FORGING SAVED 161 lbs. of BRASS per 1000 PIECES

Eye-opener savings! As high as 67% not uncommon. 25% to 40% an every day occurrence. Milford equipment for cold-heading — and experience — are unsurpassed; have cut costs for others, can cut costs for you. Since many parts now screw machined can be cold-headed, why not investigate? First step: send sample part or fastener. Milford engineers will carry on from there. No obligation.

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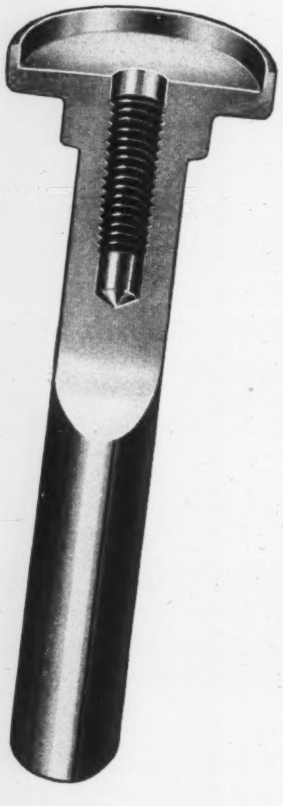

transformed into an equation whose roots are even higher powers of the given roots, it would be discovered that one set of the double products of the x^2 term would not disappear, and that the trigonometric term would change sign as the amplitude increases. These two observations reveal that complex roots are present. Real roots a and b can be determined in the usual manner. If the original equation be depressed by $\pm a$ and $\pm b$, the quadratic formula can be used to determine the complex roots. Otherwise, r can be obtained from the two coefficients adjacent to the trigonometric terms, Equation 11, inasmuch as $a^m r^{2m}/a^m = r^{2m}$. Further, writing $re^{+j\theta}$ and $re^{-j\theta}$ as $(u + jv)$ and $(u - jv)$, their sum is $2u$, hence u can be obtained from the relationship $-A_1 = a + b + 2u$ and v can be obtained from the relationship $r^2 = u^2 + v^2$.

As an example of an equation having complex roots, it is required to solve

$$x^5+5.50x^4+x^3-x^2+1.50x-1.00=0$$

Computations are shown in TABLE III. The behavior of the x^2 terms reveals that complex roots are present. From the final line of the table

$$\log a=\frac{\log\ (1.16\times 10^{23})}{32}=0.721 \qquad \therefore\ |a|=5.26$$

$$\log b=\frac{\log 1.22-\log 1.16}{32}=0.00069 \qquad \therefore\ |b|=1.00$$

$$\log c=\frac{\log 1.00-\log (4.91\times 10^{9})}{32}=-0.303 \qquad \therefore\ |c|=0.497$$

$$\log r^2=\frac{\log\ (4.91\times 10^{9})-\log\ (1.22\times 10^{23})}{32}$$

$$=--0.419 \qquad \therefore\ r^2=0.382$$

Signs determined by depressing the original equation by $\pm$ values of the foregoing absolute values give $a = -5.26$, $b = -1.00$, and $c = +0.497$. The sum of these with the sign changed is $+5.76$, and A_1 in the original equation is 5.50, hence $u = -\frac{1}{2}(5.50 - 5.76) = +0.13$, and $u^2 = 0.0169$. But $r^2 = u^2 + v^2$, therefore $v = \sqrt{(0.382 - 0.017)} = \pm 0.605$, and the complex roots are $+0.13 \pm j0.605$.

Doherty and Keller[1] give examples and rules for all the preceding cases as well as for four distinct complex roots, six distinct complex roots, coincident complex roots, and a seventh degree equation with two pairs of complex roots. They show that the number of coefficients which fluctuate in sign is equal to the number of distinct complex roots. For four and six distinct complex roots these will be the coefficients of the odd powers. The presence of three adjacent irregular coefficients, the outside ones varying in sign, indicates the repetition of complex roots.

For greater accuracy and more rapid computations Barlowe's Table of Squares, Cubes, etc., Crelle's Multiplication Tables, computing machines, and logarithmic tables will be found useful.

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1. Doherty, R. E., and Keller, E. G.—*Mathematics of Modern Engineering*, Vol. 1, John Wiley and Sons, Inc., New York, 1936.
2. Whittaker, E. G., and Robinson, G.—*Calculus of Observations*, Blackie and Son Ltd., London, 1924.
3. Scarborough, J. B.—*Numerical Mathematical Analysis*, The Johns Hopkins Press, Baltimore, 1930.

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Silicone News

DC
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DC Silicone Fluid Solves Toughest Damping Problem

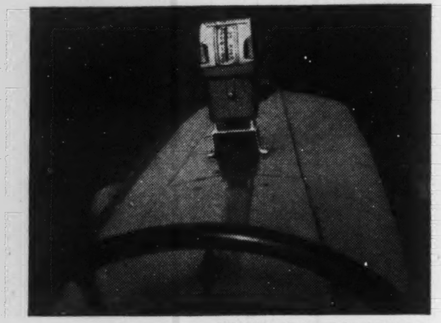

PHOTO COURTESY THE ELLIS SALES CO.

Constant Viscosity of DC 200 Fluid in Ellis "Contourliner" makes contour plowing easy and accurate.

A new, ingenious device made farm paper headlines recently when the Ellis Sales Company of Fairfield, Iowa, announced the "Contourliner"—an instrument for scientifically maintaining accuracy in contour plowing.

Previously it has been necessary for the farmer to survey his field, and put stakes along the contour line to serve as guide marks when plowing. The "Contourliner" eliminates all this extra work. Mounted on the hood of the tractor in plain view of the driver is an easy-to-read dial calibrated to show which way the tractor is deviating—to show how much in per cent of slope—to tell the driver which way to turn to get back on the contour.

Since tractors travel over extremely rough ground, a damping fluid was needed to prevent tractor vibrations from interfering with the accuracy of the instrument. The problem was to find a damping fluid that would retain a constant viscosity over a wide range of temperatures.

Many different types of oils were first tried as a damping fluid. Temperature variations, even during a normal summer day's operation, so changed the viscosity of these oils that accurate indication was impossible.

DC 200 fluid, suggested by Dow Corning engineers, proved to be the answer. Since DC 200 fluid has the ability to maintain almost unchanged viscosity from —40° F. to 400° F., it was of course unaffected by seasonal temperature changes. Stability under all types of conditions is a common characteristic of all Dow Corning Silicone products, including resins, varnishes, greases, and Silastic*, our silicone rubber. Dow Corning Silicone products are described in Catalog B 1-5.

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SILASTIC*
- Molding
- Extruding
- Coating
- Laminating

*Trade Mark Dow Corning Corporation

Slant Mechanisms

(*Continued from Page* 140)

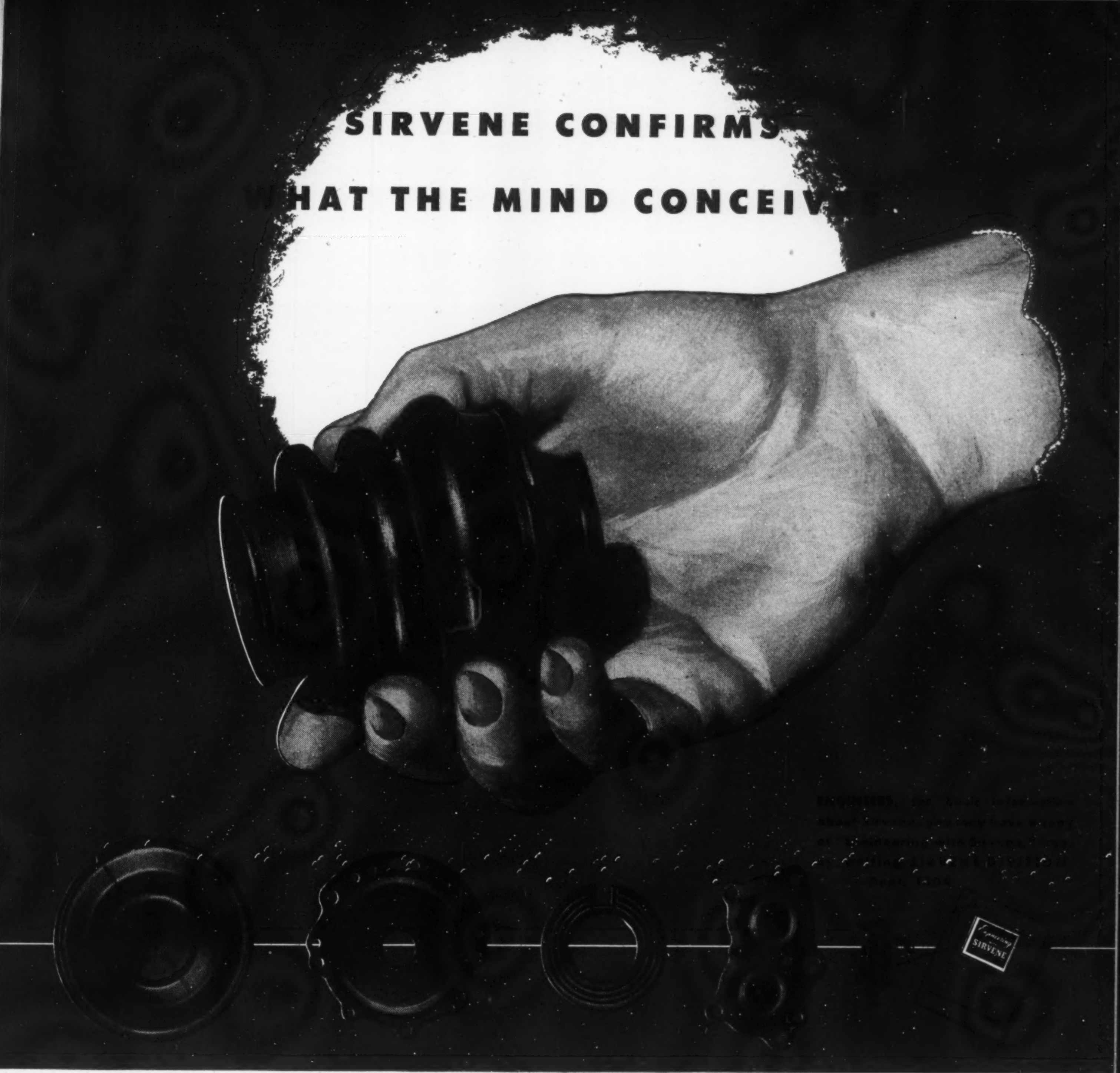
joints. That at the piston has only a small oscillating movement (at twice engine speed) occasioned by the angularity of the rod with respect to the cylinder axis. At the cage end the movement is much greater as it involves the angle of dip of the slant. The continuity of the motion is favorable to good bearing action and the release of loading during the compression stroke enables the oil film to be replenished. Both joints have always behaved satisfactorily. Owing to this good performance the ball size was reduced in the second and third engines from that originally decided upon. The sockets have been tried with both silver and lead-bronze linings with about equal success. The author prefers the latter, particularly at the piston end for best possible bonding.

The torque rollers on the cage extensions are of hardened—55 to 58 rockwell C—SAE 52100 steel, with electrolytic silver lining. The guide plates are of similar material and hardness. Originally the surface of the roller track on the guide plate was ground with a radius of curvature somewhat greater than that of the roller (spherical). This was done to provide a wider line of contact. Experience showed this to be unnecessary. Flat ground guide plates have performed equally well. No roller or guide plate of the type shown in *Fig.* 8 has ever been injured in normal operation.

Slipper Pad Performance

The kernel of the slant mechanism is the pivoted slipper pad. On its reliability and efficiency depends the practicability of this form of construction. Theoretically the functioning of an unsymmetrically pivoted slider is the most perfect fluid bearing known. It has superior shock resistance, load capacity, and high-speed characteristics, and possesses inherent ability to adjust itself for optimum performance in applications where variations in load, surface speed and viscosity of lubricant exist. Tests on full-scale slippers in a specially built testing machine show coefficients of friction less than 0.001 for loads of the order of 2500 psi at a velocity of 250 fps. Under average loading during the loaded interval in an opposed-piston, two-cycle engine it is estimated that a coefficient of 0.003 will not be exceeded. In the test machine the slippers have been operated at 2500 psi continuously applied for long intervals without any sign of trouble. In the engine this is the maximum momentary load lasting not more than 10 degrees rotation.

Application of the slipper pad to a very light diesel engine presented a number of practical problems. Firstly, thickness dimensions (lateral stiffness) were largely tied up with the design of major parts and there were no data available as to minimum dimensions. In early trials operation of the pad was largely bound up with the stiffness of the slants and much time was lost in obtaining newly designed parts. Slipper pad operation was uncertain in that when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Time and again Sirvene engineers serve as the hands which confirm a designer's conception. Working in Chicago Rawhide laboratories, they develop and produce the pliable parts essential to the function of his design. These unusual Sirvene parts are molded from custom-compounded formulae and verify every specification in design, elasticity or hardness, tensile strength or resilience. They are resistant to age, dryness, abrasion, wear, temperature extremes, oil, water and deterioration. When your problem involves the development of pliable parts, Sirvene offers the best solution.

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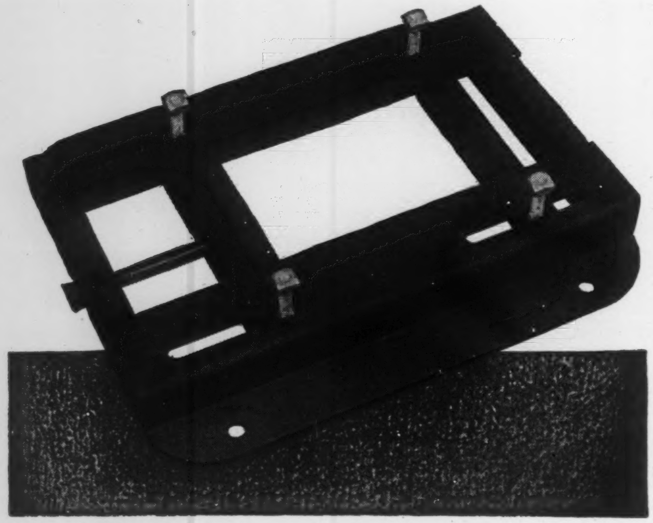

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everything would seem to be settling down satisfactorily, a sudden failure would occur within 30 seconds of starting-up even under idling conditions. The same slippers may have behaved satisfactorily the day before on substantial loads.

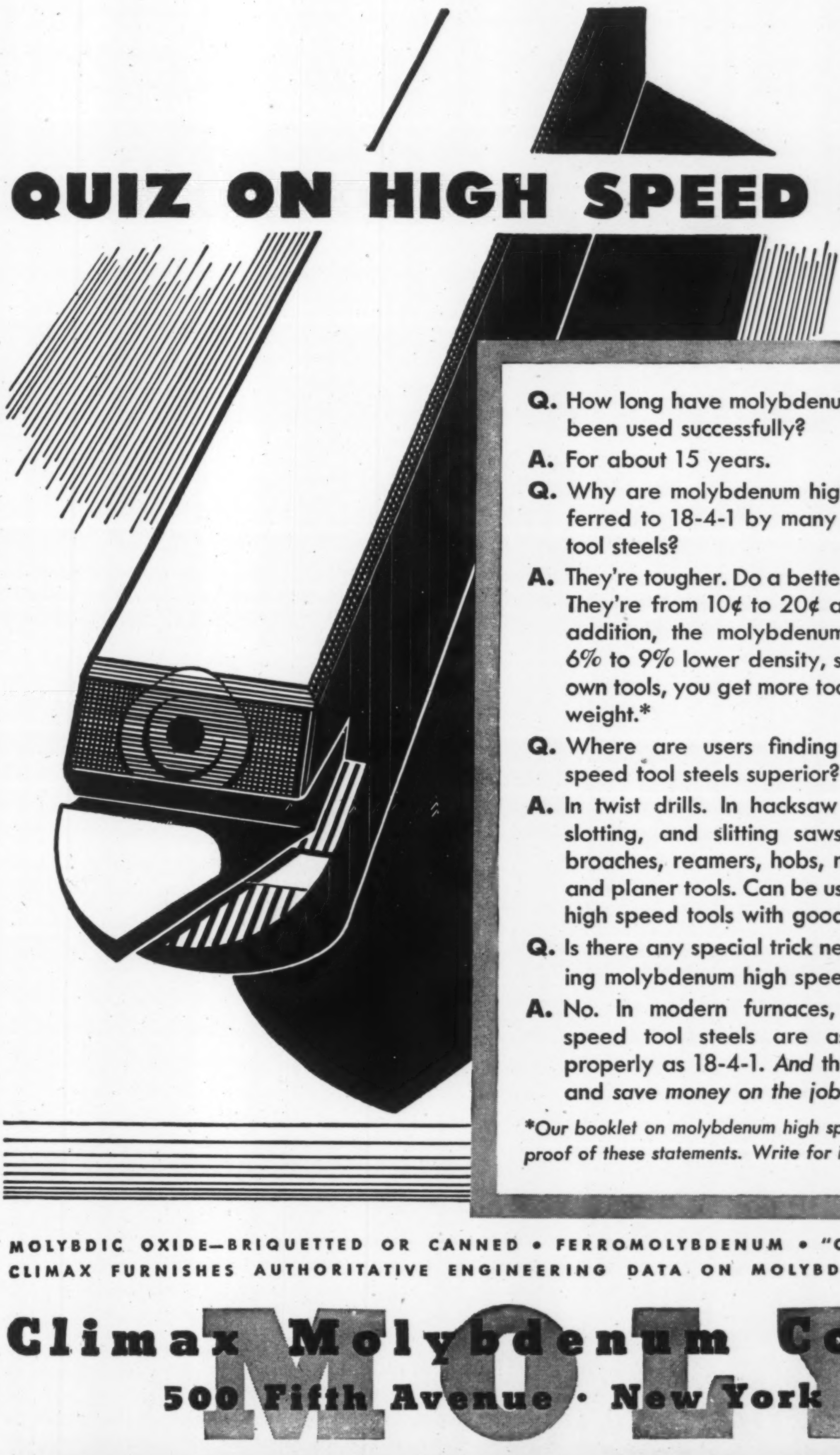
It is not difficult to imagine how much investigation went on feverishly to probe the cause of these failures. The slipper test machine always gave good results. Checking of the slant surface under static loading showed that convexity was always present. Deviation from flat measurements of 0.001-inch in 2-inch chord were rarely exceeded under the deflections caused by the applied loads from two adjacent cylinders. Various surface linings were tried out. Cadmium alloys gave no trouble but their fatigue resistance was limited to about 40 hours. Lead-bronze and silver were the objectives but these were the most uncertain, even when silver was given a coating of indium or lead. Finally it was concluded that the time characteristic of the failures pointed to conditions obtaining during stopping and starting, since the engine turns over to its last gasp and starts up very rapidly under a compression load of 13,000 to 15,000 lb.

Slipper Pad Problem Solution

Tests were then commenced in the slipper-testing machine to simulate the stopping condition. These indicated that metal to metal contacts were taking place over small part areas with change in frictional drag even at speeds of the order of 45 rpm for some materials which wetted badly. When the cage members with spherical mount location were put in hand allowance was made for a substantial increase in slipper pad stiffness. This, together with stiffer slant surfaces and a priming system which insured oil pressure at stopping and starting, turned the trick. The engine is at present fitted with lead-bronze-faced slippers at one end and a plated cadmium-silver alloy at the other. These were fitted to the engine almost a year ago and have behaved perfectly ever since. Definite attempts to spoil them by "stopping" have failed to do any damage. The engine has been stopped more than 100 times and has been operated more or less continuously since that date without slipper trouble of any kind. The lead-bronze facings have now acquired a dull brown appearance with no bright spots or evidence of self repair.

It is easy of course to be wise at this date and wonder why the same solution could not have been effected earlier. In the first place it was not always possible to make the simple decision to increase the thickness of the slipper. This involved changes in other parts which would have required considerable time to effect. Furthermore, because of many other considerations, the issue was beclouded. Thickness increments up to the maximum permissible by other restrictions were made but we know now that the amounts were insufficient. At this date substantial improvements in the detail design of the slipper pad are known and this fundamental part, which is so essential to successful introduction of the slant mechanism, can no longer be regarded as unproven, nor are any particular risks involved in its use in engines for commercial or other purposes.

QUIZ ON HIGH SPEED STEELS



Q. How long have molybdenum high speed steels been used successfully?

A. For about 15 years.

Q. Why are molybdenum high speed steels preferred to 18-4-1 by many large consumers of tool steels?

A. They're tougher. Do a better job for less money. They're from 10¢ to 20¢ a pound cheaper. In addition, the molybdenum steels have from 6% to 9% lower density, so if you make your own tools, you get more tools for a given gross weight.*

Q. Where are users finding molybdenum high speed tool steels superior?

A. In twist drills. In hacksaw blades. In milling, slotting, and slitting saws. In taps, chasers, broaches, reamers, hobs, milling cutters, lathe and planer tools. Can be used for all classes of high speed tools with good results.

Q. Is there any special trick needed in heat treating molybdenum high speed tool steels?

A. No. In modern furnaces, molybdenum high speed tool steels are as easy to harden properly as 18-4-1. *And* they cost much less—and *save money on the job.*

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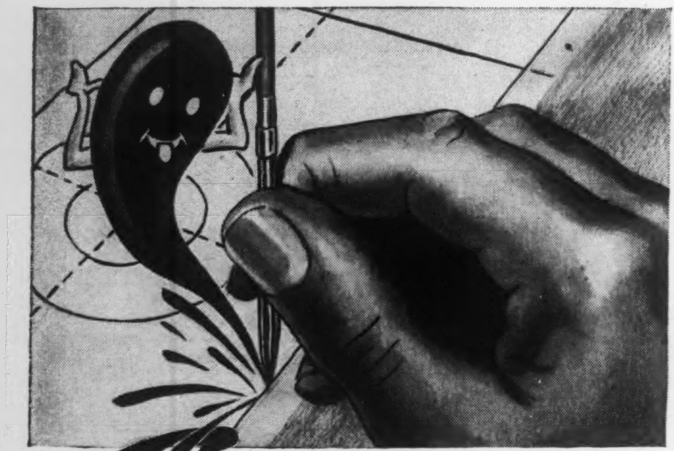

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BUSINESS AND SALES BRIEFS

ELECTION of two new vice presidents of the Mechanics Universal Joint Division of the Borg-Warner Corp. has been announced recently. C. E. Palmer, former works manager, was named vice president in charge of manufacturing for the division's two plants. The other newly elected vice president, Fred M. Potgieter, will have charge of truck, agricultural implement, industrial and aviation sales. G. C. Gridley was re-elected president and general manager and R. R. Rolph was re-elected vice president in charge of automotive sales.

◆

Change of control of Cordage Inc. accompanied by a change in name to Koiled Kords, Inc. has been announced by the new president John Brown Cook. The new corporation is owned by the Whitney Blake Co. of New Haven and the west coast interests of Ralph Collins and Charles F. Mason. Sales activities of the new organization will be directed by Col. E. L. Love, who was formerly in charge of Koiled Kords Division of the Kellogg Switchboard Co. in Chicago.

◆

Production manager of Koppers Co. Inc. since May, Hugh C. Minton has been appointed vice president of the company by president Brehon Somervell. General Minton directed the Army Service Forces production division during the war reporting, in that capacity, directly to General Somervell who was commanding officer of the Army Service Forces.

◆

Now located in Highland Park, Michigan, the Standard Tube Co. has broken ground in Redford Township, Mich. for an $875,000 brick and steel-frame factory. Plans call for a floor area of 142,000 square feet.

◆

Appointment of the Ridley Co., 320 11th St., San Francisco as its northern California representative has been made by the Hannifin Corp. of Chicago. Hannifin representative in southern California is Tornquist Machinery Co., 931 Santa Fe Ave., Los Angeles. The organizations will represent the Hannifin line of hydraulic and pneumatic power and production equipment.

◆

Recent appointments made by Kennametal Inc. of Latrobe, Pa. include: Gilbert A. Bunn as district manager of the Philadelphia district with offices at 3701 North Broad St., and Ralph L. Miller as representative in the Reading, Pa., area with headquarters at the Philadelphia office. Also Hugh A. Pilling has been appointed application engineer in the Phila-

How We Beat Rising Costs by Changing to Welded Design

By Francis M. Wick, General Manager
Silver Manufacturing Company, Salem, Ohio

DESPITE the fact that costs have greatly increased in the past two years, the material costs of our "Ohio" Feed Cutter (Fig. 1) are no more today than on V-J day, due to the savings we have gained by changing to welded steel design.

The change to welded steel has also cut the machine's weight 24%, from 455 to 345 pounds—really a price decrease, since most of our sales are to foreign customers who pay duties assessed on basis of weight.

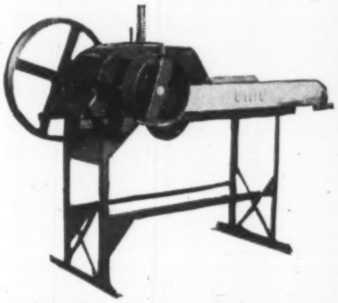
Fig. 1. The "Ohio" Feed Cutter.

We originally started experimenting with welded steel design because of the difficulty of getting a regular flow of parts. Our welding department has not only eliminated production bottlenecks, but has enabled us to increase production 79% with only a 20% increase in employees. The chief reason for this is that the parts of welded steel require much less machining, grinding and fitting than the former material. The same man-hours we formerly put into finishing now are used to prepare raw materials for the welding department and handle all finishing.

An example of cost reductions on the individual parts is the hood (Fig. 2). The hood made by the former method cost $1.99. We now fabricate it from three pieces of 12-gauge mild steel, flame-cut and brake-formed, for 94.3 cents, a saving of 52½%. Weight is also cut in half, from 17 to 8.5 pounds.

One of the interesting changeovers to welded design is the corrugated roll and shaft (Fig. 3). Weight was reduced from 18.5 to 11 pounds. The corrugated roll is now made of twelve angles, ⅛″ x 1″ x ⅝″. Six of them at a time are inserted in a special jig and tack-welded together to form a half cylinder. The end discs, stamped from 12-gauge sheets, are slipped over the shaft and held in position for welding in a cradle-type jig. Then, using another special jig, the two corrugated halves are tack-welded to the discs. Tack welds give sufficient strength.

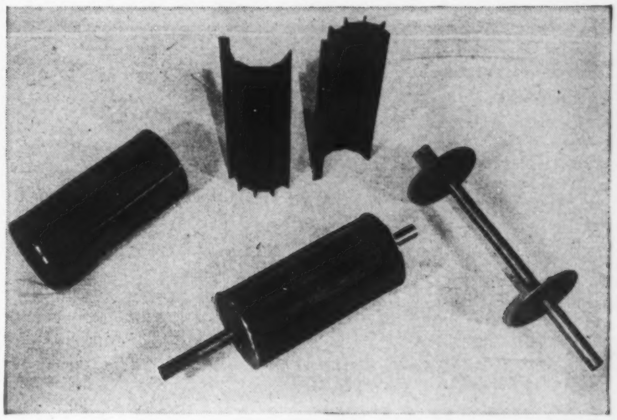
Fig. 3. At left is former corrugated roll. New welded roll and shaft (center) are fabricated from steel shapes as shown.

Welding the shaft and roll as an integral unit eliminates the man-hours formerly spent in machining and broaching keyways—a troublesome job.

In redesigning the flywheel (Fig. 4), weight was removed from the center, where it has a low moment of inertia, and concentrated on the rim, where it has the best effect. Thus the welded steel flywheel weighing 56 pounds has the same efficiency as the former design of 72 pounds.

The flywheel O.D. is 24″. The rim is a 2″ x 1¼″ mild steel bar approximately 6′ long which is heated, rolled and welded. Spokes are 3/16″ x 2½″ bars, drilled and broached at the center to match the hub of cold drawn tubing spaced between them. Welding is done in a jig which has a center post to hold the spokes and tubing in alignment, and three jaws which center the rim around the spokes. Each spoke is welded to the rim with a single pass, and two large tack welds join the hub to the spokes.

Other parts we have converted to welded design are the side plates, pulleys and smooth roll. The frame, formerly bolted, is now arc welded. All welding is done with "Fleetweld 7" electrode.

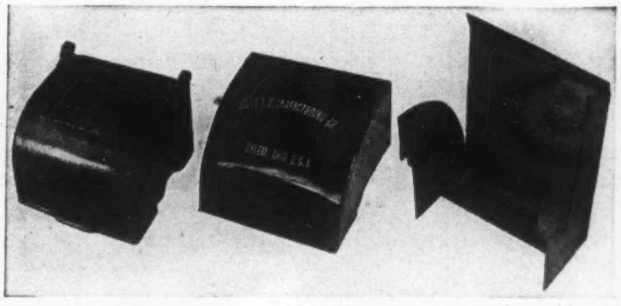
Fig. 2. Welded steel hood (center) costs 52% less than former design (left). How welded hood is made is shown at right.

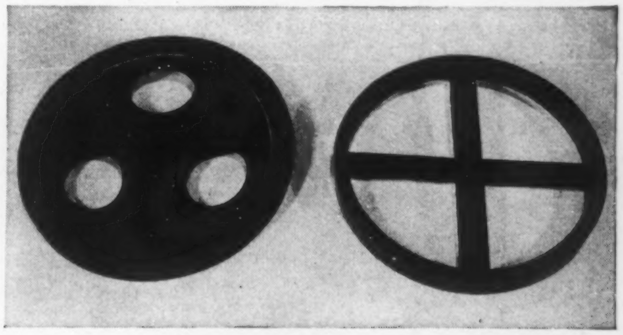
Fig. 4. The old flywheel was replaced by welded design (right) which weighs 23% less, but is just as efficient.

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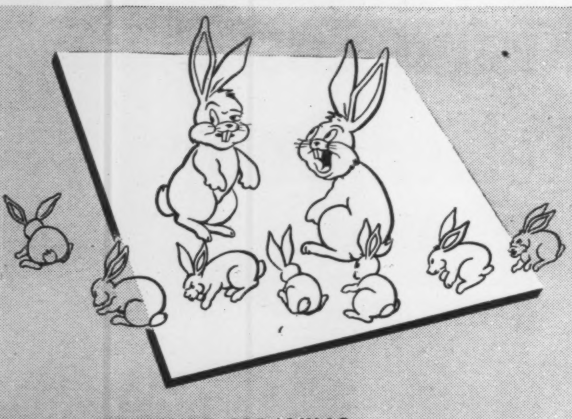

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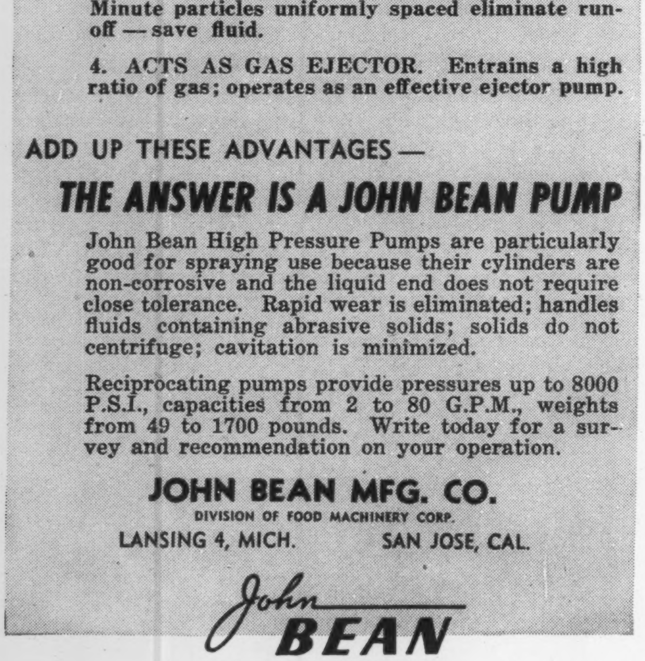

delphia district. In New England, John H. Wright will be tool engineer for the New England district with offices at 1537 Main St., Springfield, Mass. Frank E. Ryan, Jr. will also work out of this office as application engineer. For the Detroit area, Richard H. Oberholtzer has been appointed as representative, with William Dalton Huston and D. C. Cunningham as application engineers. They will work out of the office at 5531 Woodward Ave. In California, Walter C. Lavers, Joseph F. Liebscher and Charles H. Bodner have been appointed representatives with offices at 3715 Santa Fe Avenue, Los Angeles.

◆

According to a recent announcement, T. R. Coffey has been appointed manager of sales of Globe Steel Tubes company's Detroit office. Mr. Coffey will be located in the General Motors building. Prior to this appointment he served as manager of sales of the Wisconsin office.

◆

Charles Stanton has been appointed district field engineer in the Philadelphia office of Chain Belt Co., Milwaukee. He formerly held a similar position in the company's Detroit office.

◆

Girnie L. Reeves, president and general manager of Reeves Pulley Co., died suddenly on October 21 at his home in Columbus, Ind. He spent his entire life in the development of power transmission apparatus and specialized machine tool equipment. Previous to World War II his company was the world's largest manufacturer of wood pulleys and clutches. The company gave up this business to concentrate on variable-speed transmissions which it had been building since 1896.

◆

Formerly vice president and general manager of the Allen-Bradley Co., Fred F. Loock was elected president of the company at a recent meeting of the board of directors. At the same meeting, Harry L. Bradley was named chairman of the board in which capacity he will continue to be active in the corporate direction of the company. Officers who were re-elected are R. W. Whitmore, vice president and works manager, Louis Quarles, secretary, and A. F. North, treasurer.

◆

Recently appointed manager of the pump division of Fairbanks, Morse & Co., L. A. Weom succeeds Arnold Brown who has resigned. Mr. Weom has been with the organization since 1929, being successively assistant in the pump and electric department, field engineer, and manager of the pump and electric department of the St. Paul branch.

◆

More than $4,000,000 will be spent by SKF industries Inc. in its two-year modernization program according to a recent announcement by SKF vice president Thomas W. Dinlocker. Bulk of the expenditures will go for new machinery required in the

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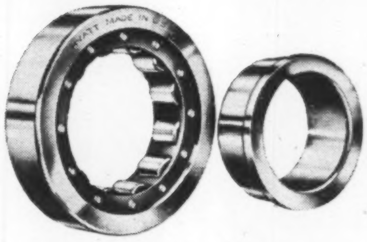
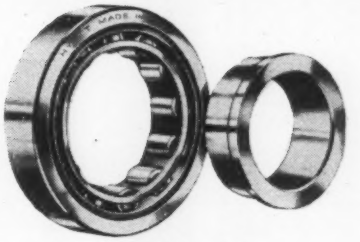
Q *When a radial bearing must also locate the shaft, what's the solution?*

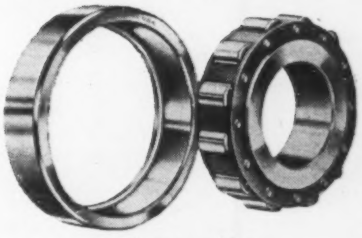
A *Any one of the five Hyatt Hy-load flanged race bearings.*



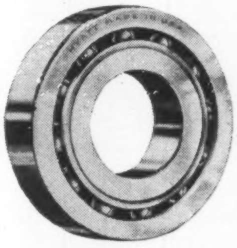
TYPE R-WB—WITH SEPARABLE INNER RACE



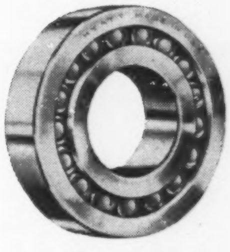
TYPE R-YS—WITH SEPARABLE INNER RACE



TYPE BU-L—WITH SEPARABLE OUTER RACE



TYPE U-YS NON-SEPARABLE UNIT



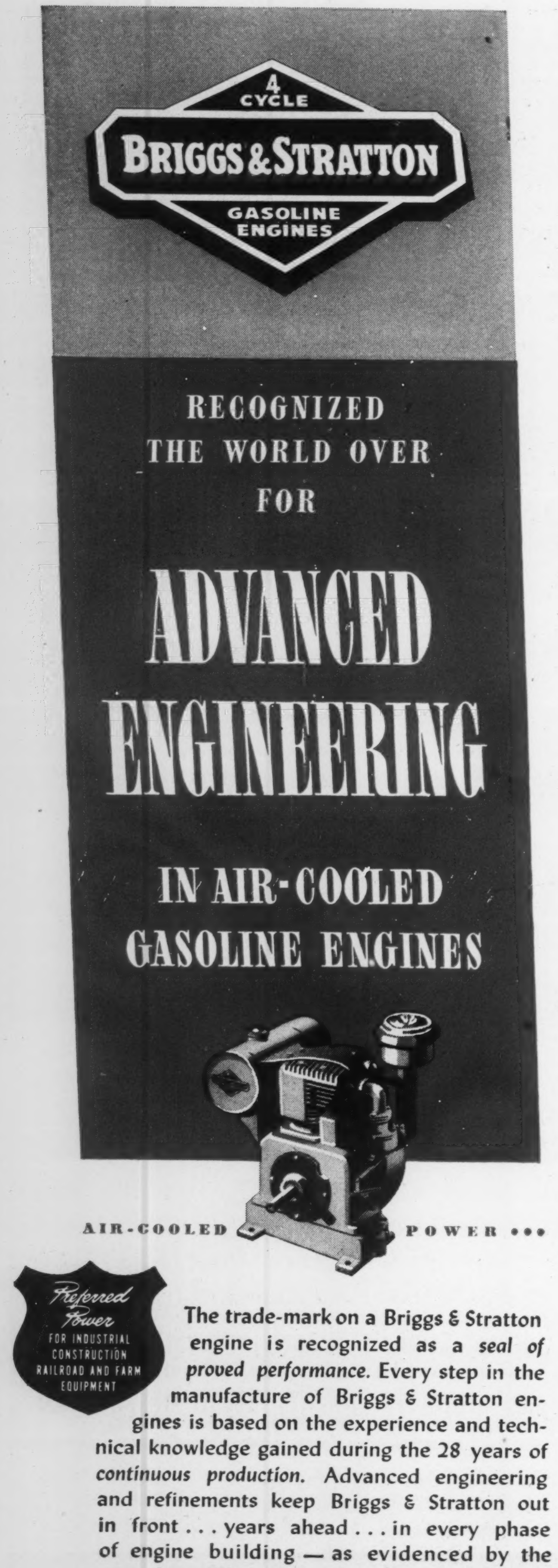
TYPE U-YM NON-SEPARABLE UNIT

You will find a Hyatt Hy-Load Roller Bearing designed to meet practically every application requirement.

The Hy-Load Bearings illustrated were designed for the many applications where the bearing load is primarily radial—but where some provision is needed for axial shaft location. These Hy-Load Bearings serve that double purpose and, when used in pairs, they can locate the shaft in both directions. This is just one of the many advantages enjoyed by designers who know the Hy-Load line, which includes ten major types.

Investigate! Ask for the latest Hyatt Hy-Load Bearing Catalog and take full advantage of our Engineering Service. If you have a difficult bearing application problem, our engineers can supply the answer. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

HYATT ROLLER BEARINGS


4 CYCLE
BRIGGS & STRATTON
GASOLINE ENGINES

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ADVANCED ENGINEERING

IN AIR-COOLED GASOLINE ENGINES

AIR-COOLED POWER ...

Preferred Power
FOR INDUSTRIAL
CONSTRUCTION
RAILROAD AND FARM
EQUIPMENT

The trade-mark on a Briggs & Stratton engine is recognized as a *seal of proved performance.* Every step in the manufacture of Briggs & Stratton engines is based on the experience and technical knowledge gained during the 28 years of *continuous production.* Advanced engineering and refinements keep Briggs & Stratton out in front . . . years ahead . . . in every phase of engine building — as evidenced by the record established by more than 3 MILLION of them in operation in all parts of the world.

BRIGGS & STRATTON CORP., Milwaukee 1, Wis., U.S.A.

production of antifriction bearings. According to Mr. Dinlocker, manufacturing will be speeded up as much as six times in some categories.

◆

New corporation for research, development and consultation work in the field of powder metallurgy has recently been formed. Known as Sintercast Corp. of America, the organization was founded by Erwin Loewy, president of Hydropress, Inc., and two associates, Dr. Claus G. Goetzel and John Ellis. Mr. Loewy is president of the new corporation.

◆

Frank A. Young, formerly representative in the Duluth, Minn. branch office of the Allis-Chalmers Mfg. Co., has been named manager of that office. An employee of Allis-Chalmers since 1923, Mr. Young is a member of the American Institute of Mining Engineers and the Engineers Club of Northern Minnesota.

MEETINGS AND EXPOSITIONS

Dec. 1-5—

American Society of Mechanical Engineers. Annual meeting to be held at Chalfonte-Haddon Hall hotels, Atlantic City, N. J. C. E. Davies, 29 West 39th St., New York 18, is secretary.

Dec. 1-6—

Exposition of Chemical Industries to be held in Grand Central Palace, New York. Charles F. Roth, Grand Central Palace, New York 17, is manager of the exposition.

Dec. 4-5—

National Warm Air Heating and Air Conditioning Association. Thirty-fourth annual convention to be held at Hotel Cleveland, Cleveland. George Boeddener, 145 Public Square, Cleveland 14, is managing director.

Dec. 4-6—

Society for Experimental Stress Analysis. Annual meeting to be held at Hotel Pennsylvania, New York. W. M. Murray, P. O. Box 168, Cambridge 39, Mass., is secretary-treasurer.

Jan. 12-16—

Society of Automotive Engineers Inc. Annual meeting and engineering display to be held at Book Cadillac Hotel, Detroit. John A. C. Warner, 29 West 39th St., New York, is secretary and general manager.

Jan. 26-29—

Refrigeration Equipment Manufacturers Association. Fifth all-industry refrigeration and air conditioning exposition to be held in the Cleveland Public Auditorium. F. J. Hood, Clark Bldg., Pittsburgh, is chairman of the show.

Jan. 26-30—

American Institute of Electrical Engineers. Winter general meeting, William Penn Hotel, Pittsburgh. H. H. Henline, 33 West 39th St., New York 18, is secretary.

Jan. 27-29—

Institute of the Aeronautical Sciences. Sixteenth annual meeting to be held in New York. Robert R. Dexter, 2 East 64th St., New York 21, is secretary.

design and production engineers'

ACME ALMAG 55 and 35

data sheet

High Tensile Aluminum Casting Alloys

ACME ALMAG 55 (heat treated)

PROPERTIES	MINIMUM	TYPICAL
Tensile strength, p.s.i.	50,000	55,000-60,000
Yield strength, p.s.i.	28,000	32,000-35,000
Elongation, 2"	16%	20% to 30%

COMPOSITION	PERCENT
Magnesium	10.0 to 11.5
Elements employed to obtain special properties	.2 to .4
Aluminum	Balance

ACME ALMAG 35 (as cast)

PROPERTIES	MINIMUM	TYPICAL
Tensile strength, p.s.i.	33,000	38,000-41,000
Yield strength, p.s.i.	15,000	18,000-21,000
Elongation, 2"	7%	10% to 15%

COMPOSITION	PERCENT
Magnesium	6.0 to 8.0
Elements employed to obtain special properties	.4 to .95
Aluminum	Balance

NOTE: Almag 55 shows tensile increase, elongation decrease on aging. Almag 35 shows practically no change.

ACME ALMAG 55 . . . strength comparable with cast or malleable iron and mild steel castings. Offers a combination of advantages never before possible . . . including beauty, machinability, and high corrosion resistance. Recommended for a wide range of uses where high strength and light weight are desired.

ACME ALMAG 35 . . . strength comparable with best previously available aluminum casting alloys but without the necessity of heat treatment. Has all the advantages required of a good alloy. Especially recommended where heat treatment is too costly or unavailable. Ingots or castings.

***ACME SERVICES:** aluminum, brass, bronze castings . . . aluminum casting alloys . . . patterns . . . tools . . . engineering . . . rare chemicals and rare metals . . . special specification alloys.*

TECHNICAL DATA
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Acme Almag 55
ACME ALUMINUM ALLOYS

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TRIPLE A

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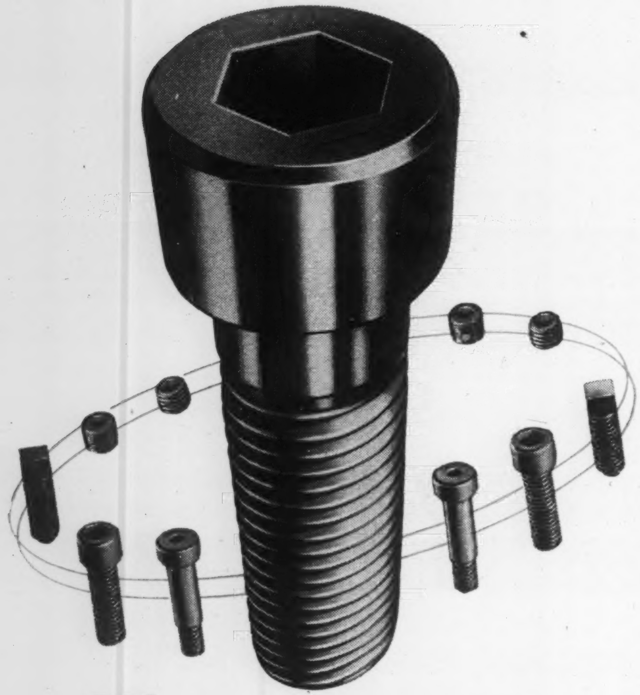
HOW BIG SHOULD A FASTENING BE?

Naturally, in the best interest of your products, fastenings should be as small and as light as possible while satisfactorily doing their job.

Chicago "Safety Plus" Socket Head Cap Screws are a high tensile, high IZOD fastening, smaller and lighter than ordinary hexagon head cap screws of equal holding power. Their use in your products means reduction in weight as well as a neater, sturdier construction.

The combination of manufacture from selected heats of alloy steel, precision workmanship and rigid inspection assures perfect uniformity for greater efficiency in your assembly. "Safety Plus" fastenings are the most economical in size and weight for your products.

Chicago "SAFETY PLUS" line includes:

Socket Head Cap Screws • Socket Set Screws • Stripper Bolts • Square Head Dog Point Set Screws • Socket Pipe Plugs • Keys for "Safety Plus" Products.

Complete line includes:

Hexagon Head Cap Screws • Square Head Cup Point Set Screws • Headless Set Screws • Fillister Head Cap Screws • Flat Head Cap Screws • Taper Pins • Milled Studs • Semi-Finished Hexagon Nuts • Semi-Finished Hexagon Castellated Nuts.

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ESTABLISHED 1872
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NEW MACHINES

And the Companies Behind Them

Laboratory

Cathode-ray oscillograph. Consists of two units: Type 281 high-voltage cathode ray indicator and Type 286 high-voltage power supply, available together or separately. Allen B. DuMont Laboratories Inc., Passaic, N. J.

Oscillograph camera for recording screen studies. Does not require that recording be taken in a darkened room to obtain adequate contrast. Also is automatically positioned for correct and fixed focus. Allen B. Du Mont Laboratories Inc., Clifton, N. J.

Microscope camera with reflex feature. Takes photomicrographs with any size or type microscope up to the largest research types. Gamma Instrument Co. Inc., New York 16.

Materials Handling

Lift truck having high lift for horizontal handling of all skids, from lowest to highest. Features a vertical hydraulic lift of 13 in. Automatic Transportation Co., Chicago 20.

Light-duty belt conveyor table and overhead empty carton conveyor, in two types: roller and slide bed. Island Equipment Corp., New York 17.

Metalworking

High-speed air drill for small drilling applications. Has speed of 26,000 rpm, and is equipped with 0-¼-in. chuck and lever throttle. Aro Equipment Corp., Bryan, O.

Lightweight ¼-inch standard duty drill. Weighs 3¾ lbs Drills steel up to ¼-inch thick and hard wood up to ½-inch thick. Aristo Power Tools Inc., Chicago 6.

Horizontal deep hole driller. Standard two-lip twist drills or single-lip gun drills can be used. National Automatic Tool Co. Inc., Richmond, Ind.

Electronic mechanical feed unit for drilling, reaming, boring, facing and tapping operations. National Automatic Tool Co. Inc., Richmond, Ind.

High-speed automatic press with automatic roll feed and variable speed drive. Has 12-ton capacity, and accommodates standard die sets 8-½ x 6-¼ in., or special die sets 8 x 12 in. Di Machine Corp., Chicago 18.

Ram type milling machine featuring an adjustable cutter head and movable ram, which permits horizontal vertical and angular milling with standard milling cutters. Van Norman Co., Springfield, Mass.

Single-ram type surface broaching machine — one of three new broaching machines being introduced. Colonial Broach Co., Detroit.

Testing

Vacuum type seal tester. Simple seals inspected at 200 per hour. Acme Scientific Co., Chicago 7.

Textile

High-speed warp knitting machine. Knits up to 168 stitches in width. Whitin Machine Works, Whitinsville, Mass.

Stainless steel fulling mill equipped with air controls. Rodney Hunt Machine Co., Orange, Mass.

Two section, full-fashioned women's hosiery knitting machine. Operates at 80 courses per minute through knitting and narrowing heel. Produced only in 54 gage at present. Robert Reiner Inc., Weehawken, N. J.

Kodak

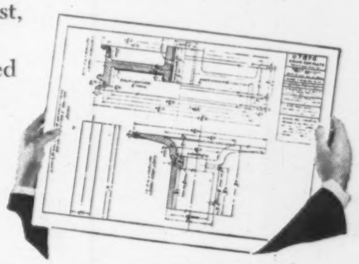
Eastman Kodak Company
announces
THE BIG NEW PLUS
in engineering drawing reproduction . . .

Kodagraph Papers

With this—the announcement by Eastman Kodak Company, world's outstanding maker of photographic materials, of a new line of reproduction papers—you'd naturally expect a big new plus. And you're getting it: first—new Kodagraph Contact Paper which brings new features, new effectiveness to existing photographic reproduction methods. Second—revolutionary new Kodagraph Autopositive Paper that brings the unique advantages of photographic reproduction to direct process and blueprinting equipment.

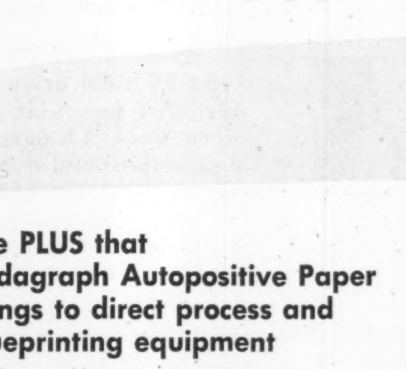
The PLUS that Kodagraph Contact Paper brings to photocopying

Photographically, you can do things that can't be done any other way. You can get better printability from old and new drawings . . . reproduce blueprints, opaque drawings. And the plus Kodagraph Contact Paper brings to this is the assurance of brilliant contrast, wide latitude, flatness, long-lived legibility, and dependable uniformity.



The PLUS that Kodagraph Autopositive Paper brings to direct process and blueprinting equipment

Truly revolutionary . . . this new Kodagraph Autopositive Paper. Exposed in direct process or blueprint machines, it brings the advantages of photography to the making of masters of new tracings for highest quality prints . . . to the restoration of "unprintable" tracings, the reproduction of blueprints or opaque drawings. Does this directly—no negatives—in your present equipment—no negatives, in ordinary room light.



See what this big new PLUS can mean to you—write for booklet

For unsurpassed photocopying—Kodagraph Contact Paper. For direct process and blueprinting equipment—Kodagraph Autopositive Paper. And for printing from reduced-scale negatives, there are Kodagraph Projection Papers. To survey the possibilities of this Kodagraph line—quickly—write for "The Big New Plus."

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Would stepless variable speed control improve your product's performance, utility or saleability?

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GYROL Fluid Drive

Bulletin No. 7019

Types VS and PE are fluid drives which provide adjustable speed control in the higher horsepower range for rotating machines such as fans, centrifugal pumps, etc. Ask for Bulletin 7019.

AMERICAN BLOWER
GYROL Fluid Drive

Bulletin No. 7119

Type SC fluid drive is the ideal drive for a wide variety of machines. Advantages are stepless speed control, no-load starting, shock absorption, acceleration control and torque limitation. Ask for Bulletin 7119.

AMERICAN BLOWER
GYROL Fluid Drive
TYPE T

Bulletin No. 7419

Type T fluid drive for electric motors is widely used on conveyors, draw-benches, winches, agitators, pumps and a host of other machines. Be sure to ask for Bulletin 7419.

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TYPE T

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Type T fluid drive for internal combustion engines. Absorbs shock, prevents engine from stalling, reduces shifts, assures a smooth load pickup, simplifies operation and reduces maintenance. Ask for Bulletin 7519.

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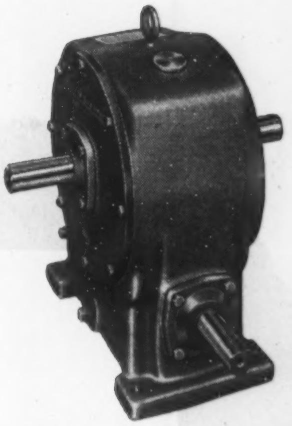
A

AMERICAN BLOWER

Division of AMERICAN RADIATOR & Standard Sanitary CORPORATION

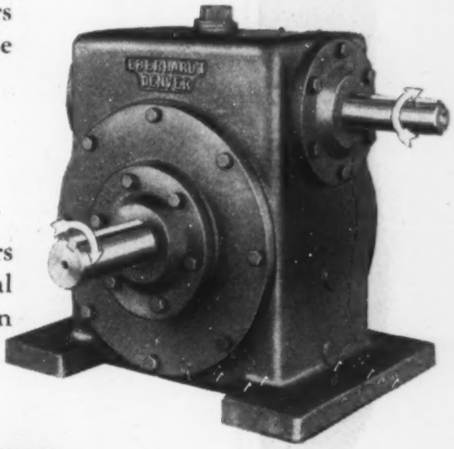
IN STOCK
OR
PROMPT DELIVERY

COMPLETE LINE
Eberhardt-Denver
WORM GEAR SPEED REDUCERS...



STANDARD ON-THE-SHELF LINE

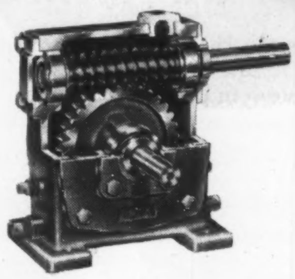
On many of your gear reduction applications you can take advantage of this standard line of small worm gear speed reducers . . . and save the time and expense of making special reduction units. These "In Stock" reducers are available in 29 models, single and double reduction, horizontal and vertical.



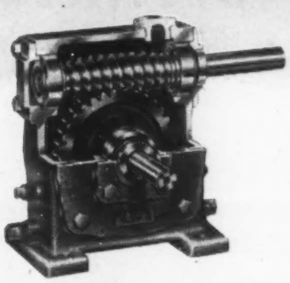
STANDARD OR CUSTOM BUILT HEAVY DUTY REDUCERS

A standard line of 12 heavy duty reducers are available for prompt shipment, or special reduction units will be built to your own specifications.

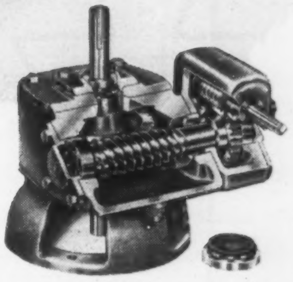
QUALITY REDUCERS



Worm and shaft are integral . . . worm is hardened, ground and polished.



Worm gear is made of high grade gear bronze with generated teeth.



Worm and gear shaft are carried on Timken tapered roller bearings.

QUALITY GEARS FOR 20 YEARS

Eberhardt-Denver Co.

1408 WEST COLFAX
DENVER, COLORADO

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Gentlemen: Please send me your worm gear Speed Reducer Catalog and advise name of your distributor in this territory.

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of this FAMOUS FAMILY

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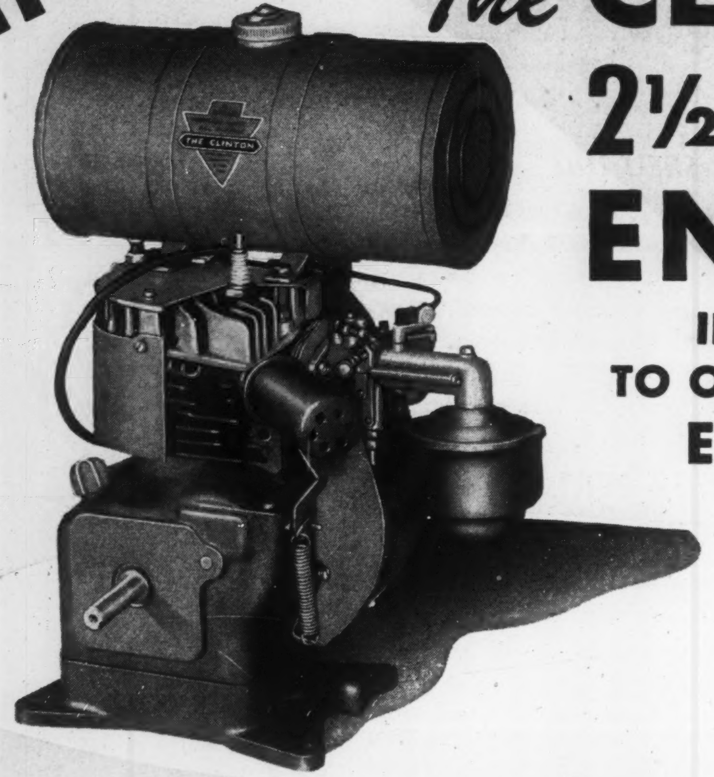
The CLINTON
2½ to 3 H.P.
ENGINE
IN ADDITION
TO OUR 1½ to 2 H.P.
ENGINES



4
CYCLE
The Precision Built
THE CLINTON
AIR COOLED
ENGINE
THE CLINTON
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IT'S POWERED BETTER WHEN CLINTON POWERED

DESTINED TO BE FAMOUS

Here's a husky—strong—more H. P.—which can stand by itself. . . . We expect a great future for this 2½ to 3 H. P., 4-cycle, air-cooled engine. It is now in production by the world's largest manufacturer specializing in 1½ to 2 H. P. Gasoline Engines.

Yes, we expect great things of this engine. . . . It's New—It's Modern—It's the most outstanding advancement in the fractional H. P. Gasoline Engine field in years. The sound engineering design—the outstanding performance in tests—the acceptance by those who have seen it makes us believe we have a winner under any condition.

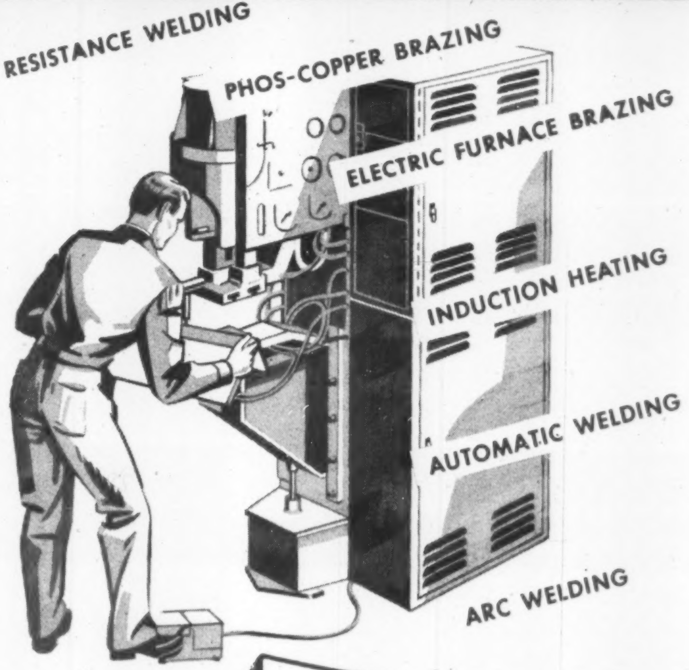
You'll welcome this finer quality engine—its DURABILITY—its ABILITY to stay on the job—its attractive PRICE are certain to give it a place in the heart of users, dealers and manufacturers employing compact air cooled power. After you've tested it on your own equipment, you will realize it's a winner.

CLINTON MACHINE COMPANY
Box 100 MD
CLINTON, MICHIGAN

Use these IMPROVED

METAL-JOINING METHODS

TO PRODUCE *BETTER* • *FASTER* • *CHEAPER!*



Approximately 20 percent of all production costs in American factories can be attributed to metal-joining. So, here is an important operation to examine for possible application of improved production equipment and methods.

Westinghouse manufactures most types of metal-joining equipment—and has gained the experience of applying this equipment in a wide range of industries, as well as in its own manufacturing operations. Whatever your metal-joining problem, Westinghouse can provide the *right* equipment and methods to perform nearly any job.

On the next two pages are examples of seven *proved* production methods, already working in many plants. Any one of them may help you turn out your products *better . . . faster . . . cheaper!*

FOR EXAMPLE . . . **If you assemble small parts in your plant:**

1. Must you increase production and cut costs in joining sheet metal?
2. Do you need a mass-production method of joining small but heavy metal pieces of uniform sizes?
3. Are castings slowing down your production . . . by slow deliveries, rejections, weight or bulkiness?
4. Do you need a quick and cheap method of joining copper or copper-alloys without the use of flux or acid?

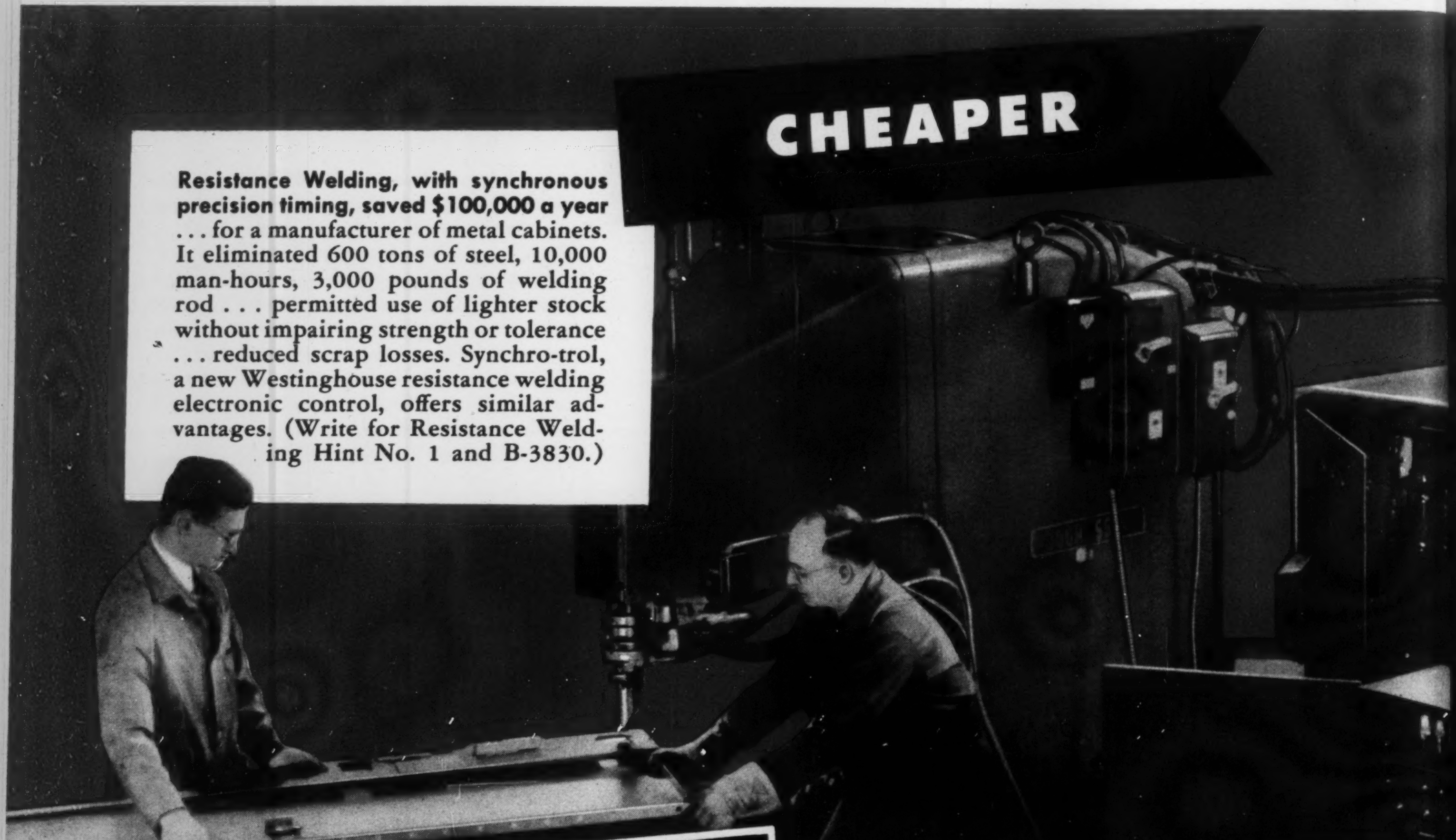
For answers to questions like these . . . turn the page

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Investigate these PROVED METAL-

TO CUT COSTS, SAVE TIME,



CHEAPER

Resistance Welding, with synchronous precision timing, saved $100,000 a year . . . for a manufacturer of metal cabinets. It eliminated 600 tons of steel, 10,000 man-hours, 3,000 pounds of welding rod . . . permitted use of lighter stock without impairing strength or tolerance . . . reduced scrap losses. Synchro-trol, a new Westinghouse resistance welding electronic control, offers similar advantages. (Write for Resistance Welding Hint No. 1 and B-3830.)

$85.00 savings per unit by A-C Arc Welding . . . when this company switched from casting cylinder heads to welding them of ¾″ boiler plate. Results: *better, stronger* cylinder heads . . . and *200 pounds of weight eliminated.* (For more information, write for B-3548.)

Electric Furnace Brazing cut factory costs 52% on this pump muffler by brazing separate baffles to the outer shell, instead of casting the unit as a single piece. (For equipment details, write for descriptive data DD-28-140, 28-450, 28-460.)

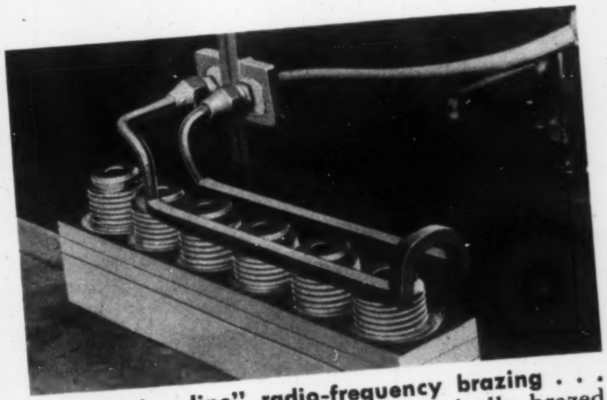
JOINING METHODS

IMPROVE PRODUCTS

Here are seven examples of metal-joining that have helped make products better, faster, cheaper. Each is a potential cost-cutter for you. For more detailed information on any of these metal-joining methods—call your Westinghouse office.

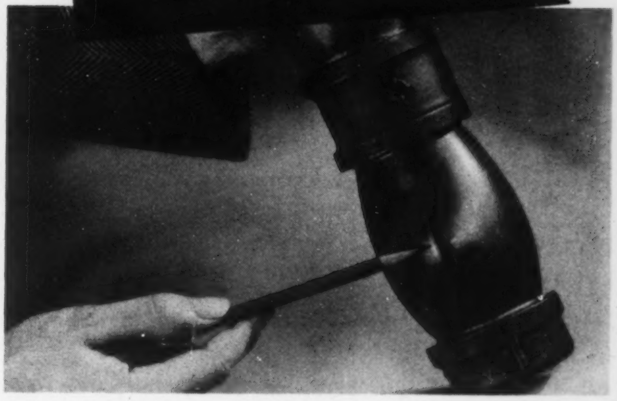
FASTER

18 pieces assembled and brazed into 6 units in 7 seconds by induction heating . . . with the aid of a simple jig. The normal method of flame brazing this steel tube assembly required two minutes to complete *one assembly of three pieces.*

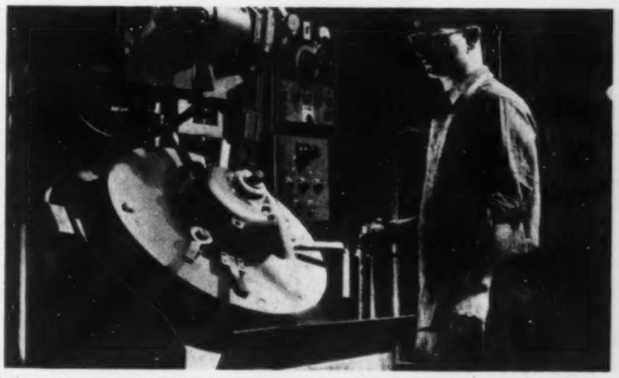


"Production line" radio-frequency brazing . . . these copper bellows are automatically brazed as a conveyer carries them through the work coil. Apparatus: radio-frequency generator, work coil and conveyer. (Write for B-3620.)

BETTER



Phos-Copper joints improved pressure resistance of joints as shown by this pressure test photo. The joints between the bronze caps and copper tube were still tight and sound when the tube burst at 2,200 psi. (Write for B-3201.)



Automatic Welding and work handling equipment . . . in motor manufacture reduced frame size 35% . . . increased power capability 116% per pound . . . tripled production. For further information, call your nearest Westinghouse office.

FOR MORE PRODUCTIVE POWER...LOOK TO

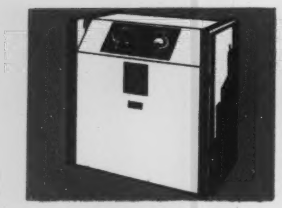
Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

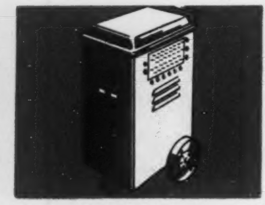
HERE'S THE COMPLETE
LINE OF WESTINGHOUSE
METAL-JOINING EQUIPMENT

FOR ANY METAL-JOINING PROBLEM Westinghouse OFFERS YOU

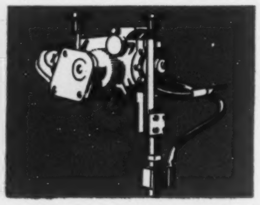
THE RIGHT EQUIPMENT..APPLICATION HELP



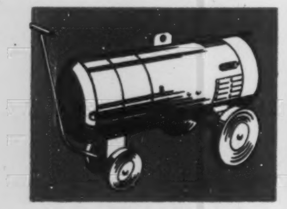
R. F. Heating Generators are built in ratings of 5, 10, 20, 50, 100 and 200 kw for induction heating. Work handling equipment available for all metal-joining applications.



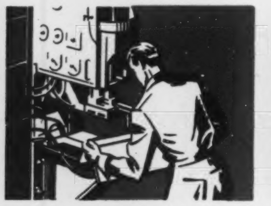
A-C Arc Welders range from 100 to 2,000-ampere capacities to handle everything from lightweight, mass-production welding to heavier structural and fabrication welding.



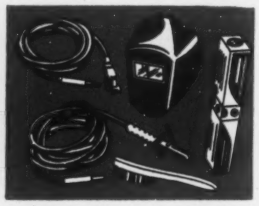
A-C Automatic Welding Heads—feed electrodes to the work continuously at an accurately controlled rate. Unit automatically starts and stops. Ideal for mass production.



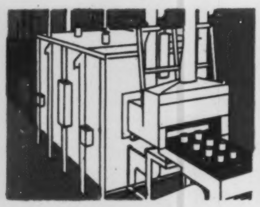
D-C Flexarc Welder... Single operator, portable or stationary motor or engine-driven sets. Available in maximum ranges up to 200 amp, 300 amp, and 400 amp.



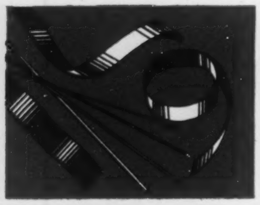
Resistance Welding Controls... SYNCHRO-TROL and WELD-O-TIMER... available for synchronous and nonsynchronous operation. Combinations to meet special needs.



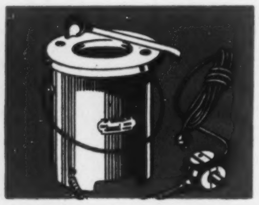
Electrodes and Accessories ... a complete range of electrodes for every type of welding, and all accessories needed—for both machine and operator.



Electric Furnaces—20 models for brazing and heat-treating metals. Five basic types of gas atmosphere generators also available, providing nine varieties of gases.



Phos-Copper is manufactured in rod, ribbon and special shapes which are particularly useful in torch, resistance, furnace and induction brazing. For copper alloys only.



Solder Pots... 10-pound and 50-pound solder capacity. 3-heat snap switch (on 10-pound size) with temperature range up to 950°F. Fully insulated.

Mail this coupon for more information

Westinghouse Electric Corporation
P. O. Box 868, Pittsburgh 30, Pa.

Please send me more information on the following products:

____**R. F. Heating**
____**Resistance Welding**
____**A-C Welding**
____**D-C Welding**
____**Automatic Welding**
____**Electrodes and Accessories**
____**Electric Furnaces**
____**Solder Pots**
____**Phos-Copper**

Name____________________ Company____________________
Title____
Address______________ City______________ State________

APPLICATION ENGINEERING

Westinghouse Application Engineering Service is available to help solve metal-joining problems in your plant. Broad industrial experience gained in our own and customers' manufacturing operations is yours for the asking.

RESEARCH

The scope of Westinghouse research reaches into every industry. Wherever power is used and distributed, this research has played an important role in doing jobs *better, faster, cheaper*. Westinghouse research facilities are available at any time to help you use new production tools and apply scientific knowledge in finding practical solutions to production problems.

TRAINING MATERIAL

Westinghouse training material covers instruction courses in such subjects as electronics and resistance welding, radio-frequency heating and arc welding. It also includes everyday help in all phases of the operation and maintenance of modern electrical equipment. This help is available in the form of *printed literature* and *training films.* Ask your Westinghouse office for full information.

MAINTENANCE

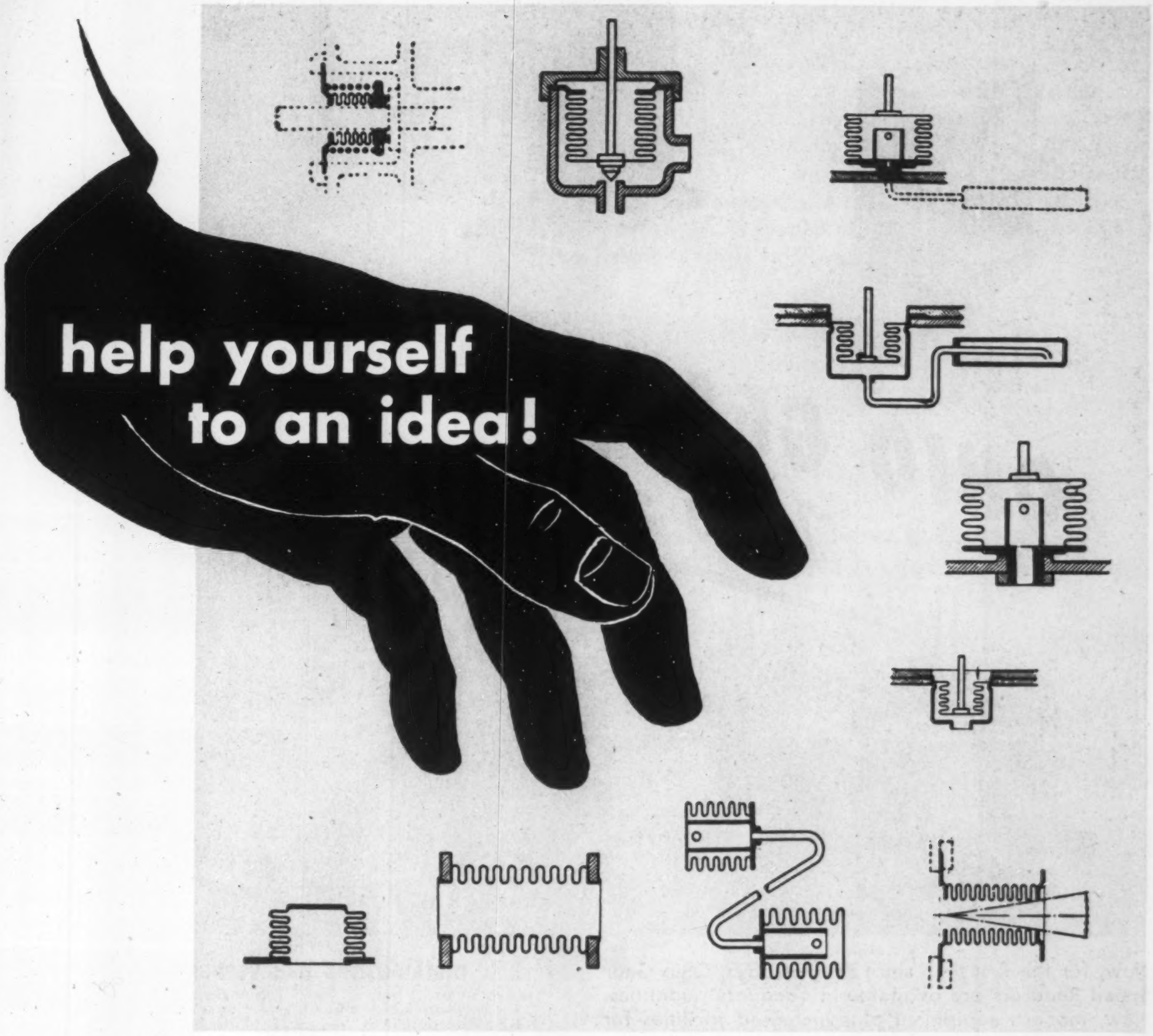
A nationwide organization of 34 Westinghouse Manufacturing and Repair Plants offers speedy, effective help on all types of electrical service and repair. A skilled staff of specialists, available through your near-by Westinghouse office, is ready to help you at any time.

J-90569

WESTINGHOUSE

PRODUCTIVE POWER

Litho in U. S. A.



FOR YEARS design engineers have been coming to Fulton Sylphon whenever they need help on design problems involving the control of pressures or temperatures. Time after time they've found that a Fulton Sylphon metal bellows, bellows assembly or device is just what they've been looking for.

It's easy to see why. Fulton Sylphon has *specialized* in the development and production of bellows assemblies and devices for over 43 years. Our engineers have helped solve all kinds of tough design problems. And never once have they "let down" on supplying a product that *delivers the performance promised.*

Perhaps you are planning a product wherein you can profitably use Fulton Sylphon bellows assemblies or devices. Write our engineers; they'll be glad to work with you. And send for catalog **VK-1200**, from which you can help yourself to plenty of useful information and ideas.

FS
FIRST WITH BELLOWS

Temperature Controls • Bellows Devices • Bellows Assemblies

FULTON SYLPHON
DIVISION

ROBERTSHAW-FULTON CONTROLS CO., KNOXVILLE 4, TENN.

Canadian Representatives, Darling Brothers, Montreal

OHIO GEAR SPEED REDUCERS
Now Available
prompt deliveries

Now, for the first time since prewar days, Ohio Gear Speed Reducers are available in adequate quantities. New, modern equipment plus increased facilities for manufacture and assembly enable us to offer all types and sizes for prompt delivery.

Ohio Gear Speed Reducers have won an enviable reputation for sound engineering, long-life and low-cost service in many of the nation's foremost industries. Guided by that reputation, design and production engineers and manufacturers everywhere are turning to Ohio Speed Reducers for the answer to their power transmission problems.

Check with us on your reducer needs. An Ohio Gear engineer will be glad to work with you. Phone, wire or write now.

THE OHIO GEAR COMPANY
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*Dayton 10, Ohio
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*N. Kansas City 16, Mo.
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*Philadelphia, Pa.
Rothman Belting & Equipment Co.
144 North Third St.

*Pittsburgh 30, Pa.
Standard Machinists Supply Co.
South 2nd and McKean Street

*Portland 4, Ore.
J. W. Minder Chain & Gear Co.
411 So. West First St.

*San Francisco 3, Calif.
Adam-Hill Co.
244-246 Ninth St.

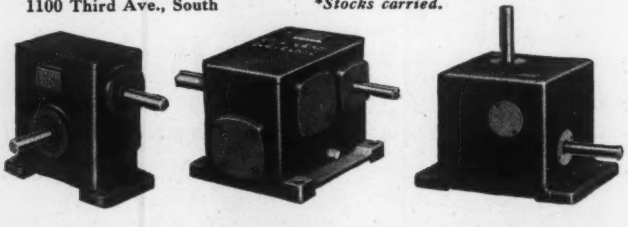
*St. Louis 4, Mo.
The Essmueller Company
1220 South 8th St.

Toledo, Ohio
The Bearing & Transmission Co.
3401 Collingwood

IN CANADA

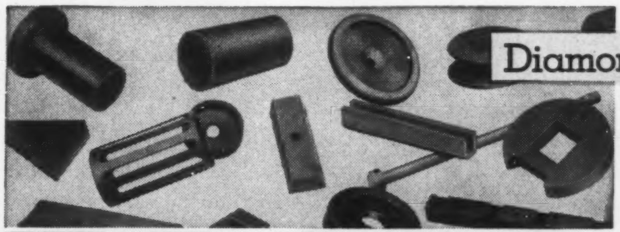
*Montreal, Canada
John Braidwood & Sons, Ltd.
66 Nazareth Street

**Stocks carried.*

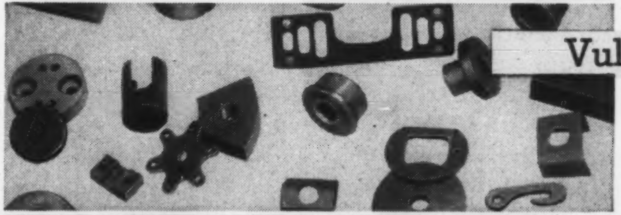


Put These Plus Factors of C-D "High-Strength" Plastics to Work

C-D offers design-engineers a variety of High-Strength Plastics in many types and grades for an almost unlimited number of applications. Each supplies the exact combination of properties for its specific job. They lend themselves readily to machining and forming on standard wood or metal working machinery.

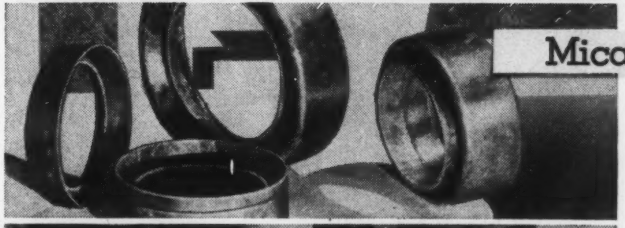


Diamond Fibre . . . Light, tough, and strong. A versatile, low cost plastic with good mechanical and electrical insulating properties. It is light in weight, dense in structure and highly abrasion resistant.



Vulcoid . . . Resin Impregnated Vulcanized Fibre. An exclusive C-D development, specially treated to retain most of the arc resistance of fibre coupled with added moisture resistance and excellent dielectric properties. Approved by Underwriters as a support material for current carrying parts.

Dilecto . . . Thermosetting Laminated Plastic. High in electrical insulating properties, structural strength and moisture resistance. Available in numerous standard grades to meet specific performance requirements.



Micabond . . . Built-Up Mica Electrical Insulation. Here is mica in its most usable forms—sheets, rods, tubes, and tapes. Maintains stability under severe heat and moisture conditions.

Celoron . . . Fabric-Base Molded Phenolic Plastic. A material with good electrical insulating properties along with high mechanical strength, moisture and heat resistance and dimensional stability.

For Help on any insulation problem, write, wire, or phone our nearest office and a C-D technician will be glad to give you the benefit of C-D experience.

For complete information on these C-D High-Strength Plastics write for BULLETIN GF-46 which gives you such basic data as: • Electrical Properties • Physical Properties • Composition of Material • Grades, Types and Sizes • Fabrication Methods • Recommended Uses.

DE-6-47

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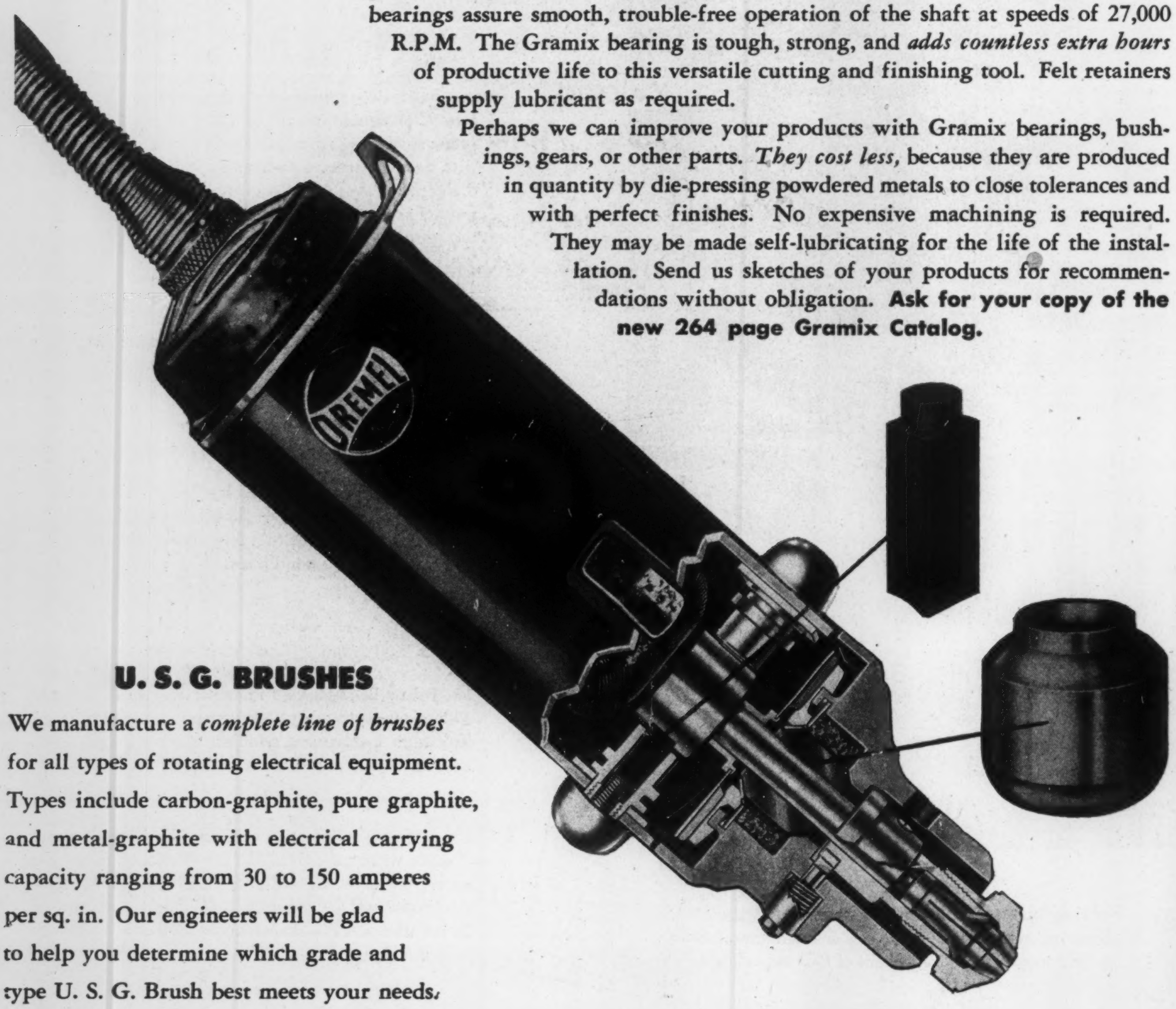
Continental-Diamond FIBRE COMPANY

Established 1895 . . Manufacturers of Laminated Plastics since 1911 — NEWARK 23 DELAWARE

gramix bearings and U.S.G. brushes help insure dependability of DREMEL Electric Moto-Tool

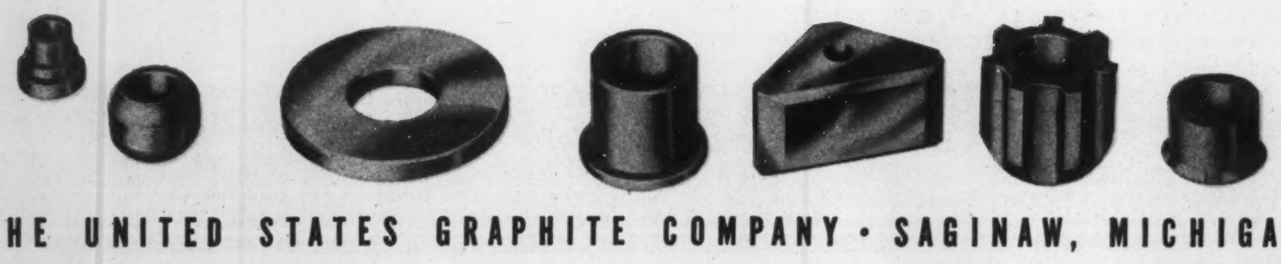
You just can't beat the Dremel Moto-Tool for efficient cutting, finishing, and polishing operations. It's fast, handy, and economical. Two of the important reasons for the top-notch performance of this popular hand tool are the *Gramix bearings and the U.S.G. Brushes* used in its construction. The U.S.G. Brushes provide long life with high torque . . . while the oversize, self-aligning Gramix bearings assure smooth, trouble-free operation of the shaft at speeds of 27,000 R.P.M. The Gramix bearing is tough, strong, and *adds countless extra hours* of productive life to this versatile cutting and finishing tool. Felt retainers supply lubricant as required.

Perhaps we can improve your products with Gramix bearings, bushings, gears, or other parts. *They cost less,* because they are produced in quantity by die-pressing powdered metals to close tolerances and with perfect finishes. No expensive machining is required. They may be made self-lubricating for the life of the installation. Send us sketches of your products for recommendations without obligation. **Ask for your copy of the new 264 page Gramix Catalog.**



U. S. G. BRUSHES

We manufacture a *complete line of brushes* for all types of rotating electrical equipment. Types include carbon-graphite, pure graphite, and metal-graphite with electrical carrying capacity ranging from 30 to 150 amperes per sq. in. Our engineers will be glad to help you determine which grade and type U. S. G. Brush best meets your needs.



THE UNITED STATES GRAPHITE COMPANY · SAGINAW, MICHIGAN

A Complete Line of Standard and Special Motors to Meet Individual Requirements

The line of type CT shaftless motors described in this bulletin is one of several lines of electric motors manufactured by The Louis Allis Co. Our specializing in the development of modern types of motors and experience in building special motors for particularly adverse conditions has been of value to us in designing and building a wide variety of motors and generators which includes the following:

General Purpose A.C. Constant Speed Squirrel Cage Motors —
    Open Protected type — ½ to 500 H.P.
    Splash-Proof — ½ to 500 H.P.
    Enclosed and Explosion-Proof — ½ to 200 H.P.
General Purpose A.C. Wound Rotor Induction Motors —
    ¾ to 400 H.P.
A.C. Multi-Speed Motors — ½ to 200 H.P.
Shaftless A.C. Motors — ½ to 200 H.P.
General Purpose D.C. Constant Speed Motors — ½ to 100 H.P.
General Purpose D.C. Adjustable Speed Motors — ½ to 50 H.P.
Direct Current Generators — ½ to 75 KW
Motor-Generator Sets — A.C. to D.C. — ½ to 75 KW
Induction Frequency Converter Sets — 1 to 100 KW
Inverted Rotary Converters — D.C. to A.C. — ¾ to 15 KVA
Special Purpose A.C. and D.C. Motors

PUMPS · HOISTS · FANS · BLOWERS · CENTRIFUGALS · MOULDERS · PLANERS
LATHES · SHAPERS · SANDERS · TENONERS · ROUTERS · BORING MACHINES
MILLING MACHINES · AUXILIARY DRIVES · SURFA S · HOISTS
CUT-OFF SAWS · GRINDERS · SENSITIVE DRILLS · TA MACHINES
PUMPS · HOISTS · FANS · BLOWERS · CENTRIFUGALS LDERS · PLANERS
LATHES · SHAPERS · SANDERS · TENONERS · ROUTERS · BORING MACHINES
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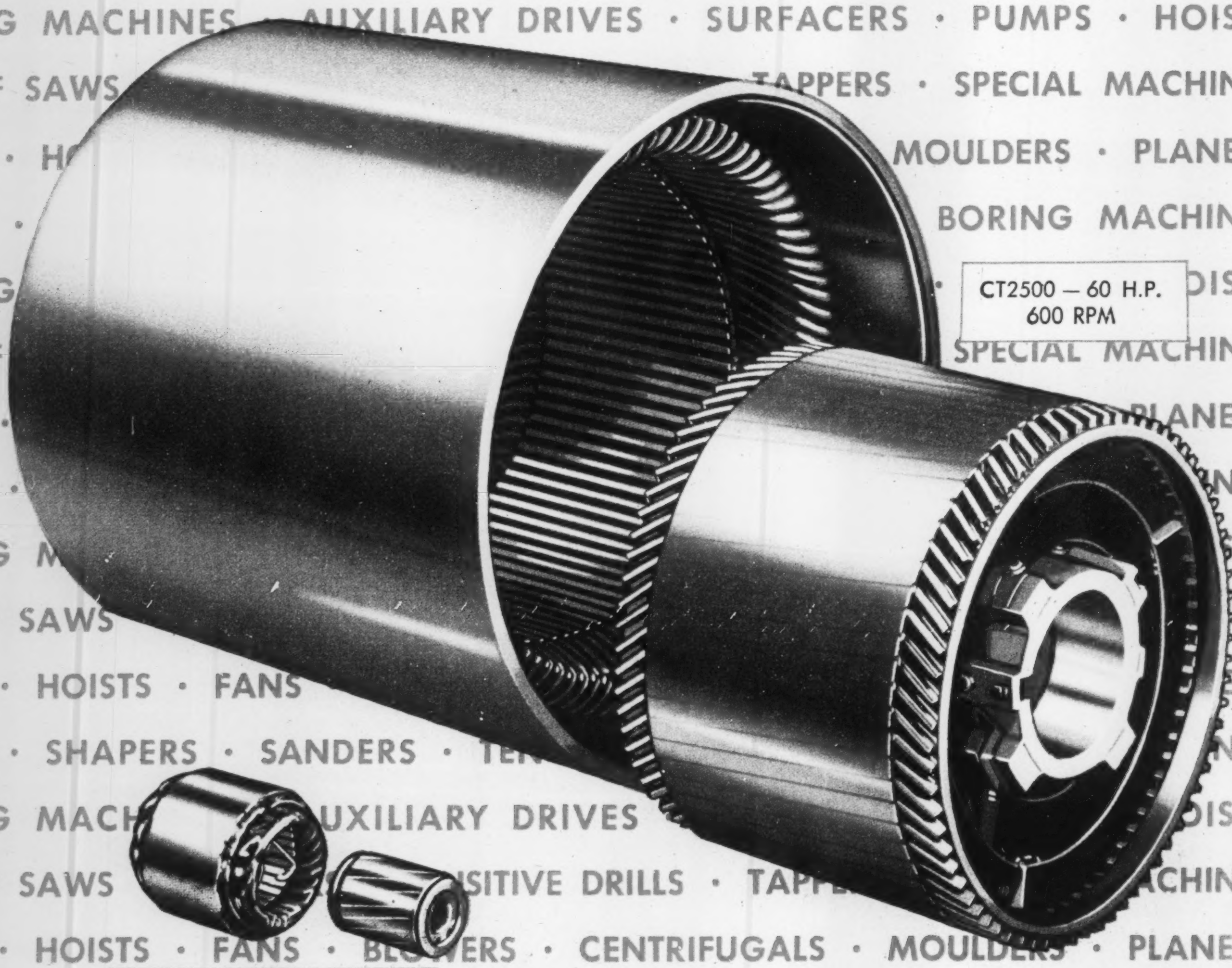
LOUIS ALLIS

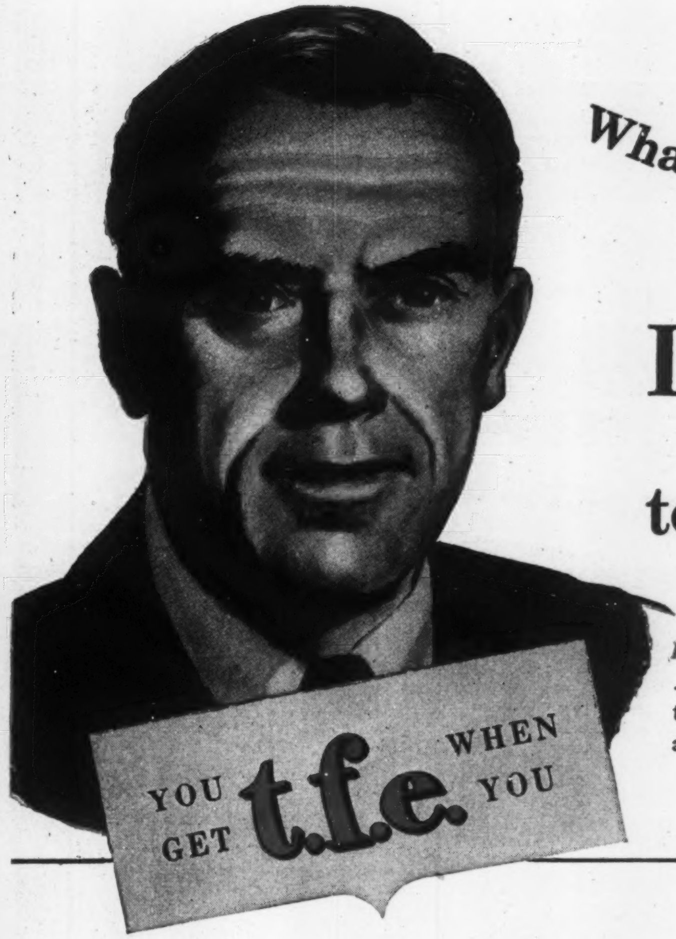


CT2500 — 60 H.P.
600 RPM

CT400 — 1 H.P. — 3600 RPM

The Louis Allis Co. pioneered in the development of motors for direct or built-in drives on which the varied and exacting requirements meant providing maximum power in minimum space. A complete and extensive engineered line of A. C. rolled shell shaftless motors is available with ample production facilities.

THE LOUIS ALLIS CO., MILWAUKEE 7, WIS.



What do Fasteners Really Cost?

There's more to fastener cost than just price. Lots more. Personally . . .

I look for all 8 to get t.f.e.

True Fastener Economy

It is the many costs of using a fastener that count . . . not just the initial price. *True* Fastener *Economy* is the lowest *total* cost for fastener selection, purchase, assembly and performance.

1. Reduce assembly time to a minimum by savings through use of accurate and uniform fasteners
2. Make your men happier by giving them fasteners that make their work easier
3. Reduce need for thorough plant inspection, due to confidence in supplier's quality control
4. Reduce the number and size of fasteners by proper design
5. Purchase maximum holding power per dollar of initial cost, by specifying correct type and size of fasteners
6. Simplify inventories by standardizing on fewer types and sizes of fasteners
7. Save purchasing time by buying larger quantities from one supplier's complete line
8. Contribute to sales value of final product by using fasteners with a reputation for dependability and finish

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

102 years making strong
the things that make America strong

RB&W
BOLTS, NUTS, SCREWS,
RIVETS and ALLIED
FASTENING PRODUCTS

Plants at Port Chester, N. Y., Coraopolis, Pa., Rock Falls, Ill., Los Angeles, Calif. Additional sales offices at Philadelphia, Detroit, Chicago, Chattanooga, Portland, Seattle. Distributors from coast to coast. By ordering through your distributor, you can get prompt service for your normal needs from his stocks. *Also*—the industry's most complete, easiest-to-use catalog.

Your
Auto Mechanic
Knows the Value
OF STAINLESS STEEL

THE lustrous, lifetime beauty of Allegheny Metal, America's pioneer stainless steel, makes it a "natural" for the external brightwork of the new cars. It's bright *all the way through*—there's no plating to wear off. What could be sweeter?

Outside the car, Allegheny Metal gives you lasting beauty . . . under the hood, it gives you lasting service. Stainless steel in crucial parts of carburetors, fuel and water pumps and exhaust systems, etc. will literally outwear the car. In fact, Allegheny Metal is ideal for *any* use where resistance to corrosion and heat are vital, and where superior strength and ease of cleaning mean more profitable operation.

We've increased the supply of Allegheny Metal—it's available *now,* in any form or shape. Learn how easy it is to fabricate, how actually cheaply it can solve many a production problem . . . **WRITE FOR ANY TECHNICAL DATA OR SPECIAL ASSISTANCE YOU NEED.**

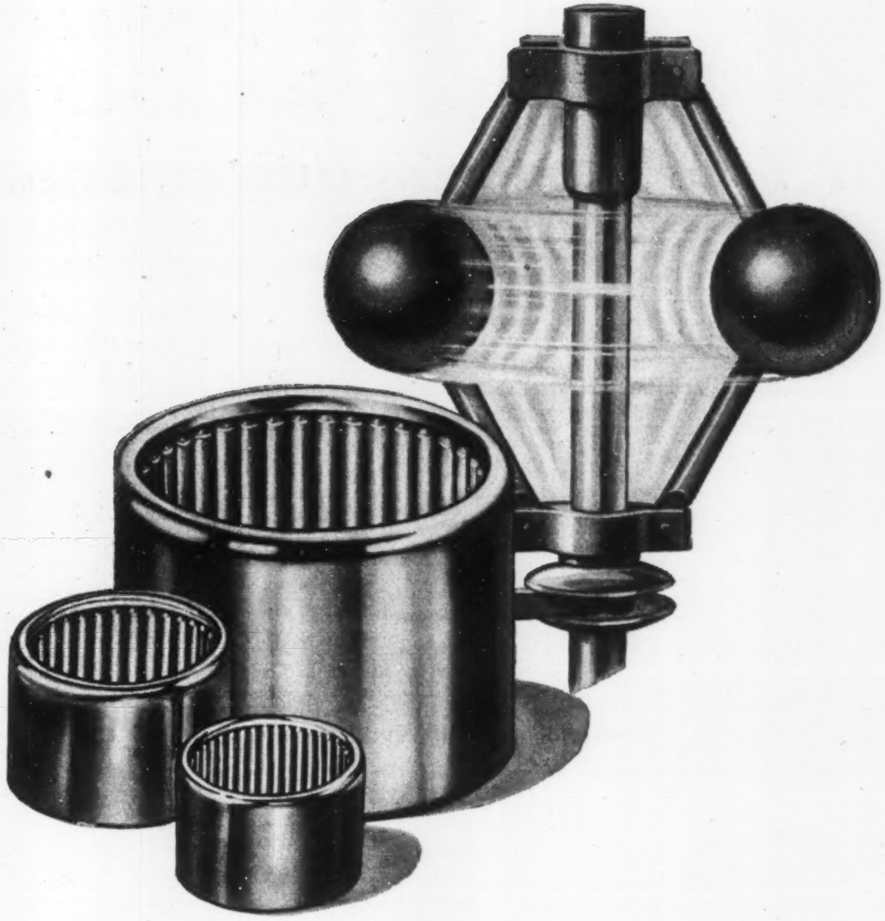
ALLEGHENY LUDLUM
STEEL CORPORATION Pittsburgh, Pa.

AL

PIONEER IN SPECIALLOY STEELS

W&D 976C

ALLEGHENY METAL is stocked by all JOS. T. RYERSON & SON, Inc., Warehouses



Govern costs, too . . .

by keeping first cost down, simplifying design, fabrication and installation, and reducing operating and maintenance expense. These advantages can be secured

With Torrington Needle Bearings.

Their compact construction permits savings in size and weight of surrounding members. Machining the housing and installing the bearings are simple, speedy operations. Their low coefficient of friction provides economy in power consumption, while their efficient lubrication prolongs the life of the bearing with a minimum of attention.

If cost is one of the factors governing your product development, it will pay you to consider these Torrington Needle Bearing features.

THE TORRINGTON COMPANY
TORRINGTON, CONN. SOUTH BEND 21, IND.
Offices in All Principal Cities

TORRINGTON BEARINGS

• NEEDLE • SPHERICAL ROLLER • STRAIGHT ROLLER • TAPERED ROLLER • BALL •

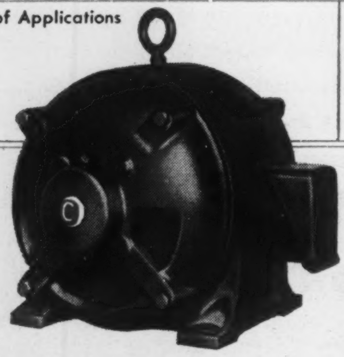
This Motor Selection Table Will Help You Select the Right Century Induction Motor for Your Power Requirements

Electrical Forms Available

Type		SC	SCH	SCT	SCX
Horsepower Range		1/6 to 400	5 to 400	1/2 to 75	40 to 400
RPM Range—Full Load		290 to 3500	830 to 1750	500 to 1500	1160 to 1750
SPEEDS	Constant Speed	Yes	Yes	Yes	Yes
	Multi-Speed	Yes	Yes	Yes	Yes
	Adjustable Speed	No	No	No	No
Starting Torque		Normal	High	High Torque High Slip	Low
Starting Current		Normal	Low	Low	Extremely Low
Type of Control Required		Use across the line starters except where limited line capacity may necessitate the use of current reducing controllers.			
Built-in Overload		Built-in overload can be furnished only for excessive temperature in the motor, through connection with pilot circuit of external magnetic starter.			

Mechanical Forms Available

Methods of Mounting					
Sleeve or Ball Bearing Horizontal	Rigid Base	Yes	Yes	Yes	Yes
	Cushion Base		1/3 to 3 horsepower only		
Ball Bearing Horizontal	Face Type Bracket Mounting	Yes	Yes	Yes	Yes
	Flange Type Bracket Mounting	Yes	Yes	Yes	Yes
Ball Bearing Vertical	Face Type Bracket Mounting	Yes	Yes	Yes	Yes
	Flange Type Bracket Mounting	Yes	Yes	Yes	Yes
Protective Enclosure	Open Type Protected	Yes	Yes	Yes	Yes
	Splash Proof		Up to 100 horsepower		
	Totally Enclosed Non-Ventilated	Yes	Yes	Yes	Yes
	Totally Enclosed Fan Cooled		From 2 to 15 horsepower		
	Explosion Proof		From 2 to 15 horsepower		
Ask For	Dimension Print	6-315	6-315	6-315	6-315
	Bulletin	6-1,P1	6-1,P1	6-1,P1	6-1,P1
Functional Character of Load to Be Driven		Note 1	Note 2	Note 3	Note 4
Typical Examples of Applications		Blowers, Fans Centrifugal pumps Machine tools Drill presses Grinders Milling machines	Excellent for Refrigeration compressors Reciprocating pumps Air compressors	Hoists, Elevators Deep well pumps Draw presses Oil well pumping Cranes, Shears Brakes	Larger sizes centrifugal pumps Unloaded compressors



Century C MOTORS

A more complete form of the above chart — including Slip Ring and Synchronous motors, will be sent to you upon request. Write today.

Note 1 — **For Moderately Easy to Start Loads.** For moderately easy to start loads or where the load is applied as the motor approaches full speed. This motor has general purpose characteristics and will cover about 90% of industrial applications.

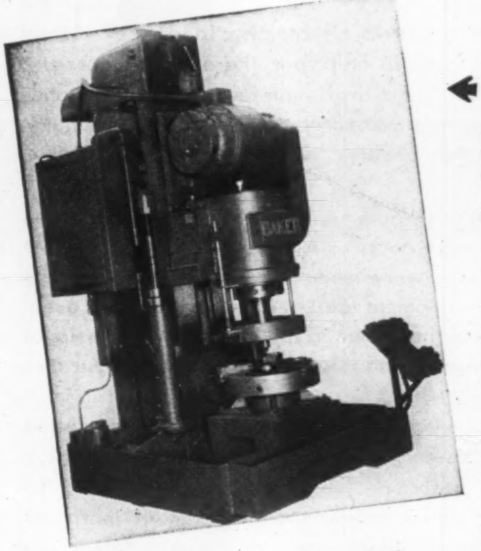
Note 2 — **For Hard to Start Loads.** Where the full load must be started from rest and smoothly accelerated to full load speed.

Note 3 — **For Hard to Start Intermittent Loads and Shock Loads.** Two types of high torque, high slip motors — one for shock loads like hoists — cranes — elevators or similar intermittent duty. The second for fluctuating loads susceptible of absorption by inertia of rotating parts like shears — brakes — draw presses.

Note 4 — **Where Load Starting Current Is Paramount and Load Easy to Start.** A saving in otherwise expensive control is also often possible.

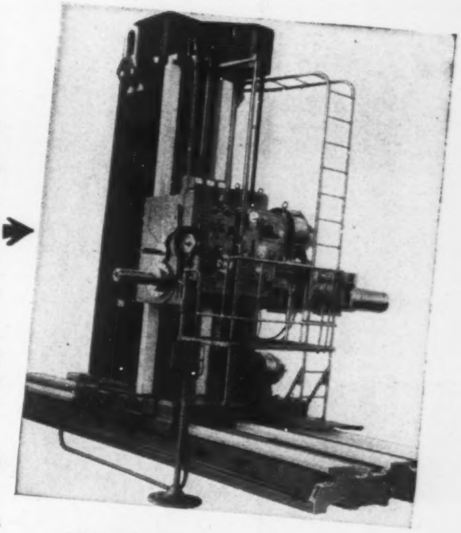
CENTURY ELECTRIC COMPANY • 1806 Pine Street • St. Louis 3, Missouri

Offices and Stock Points in Principal Cities



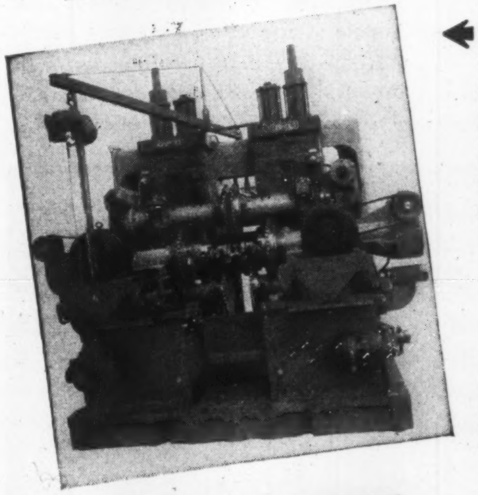
BAKER BROTHERS 40 HP BORING & DRILLING MACHINE.

Cone-Drive to the spindle "gives powerful but smooth transfer of power" to the CARBIDE tipped multiple blade cutter head.



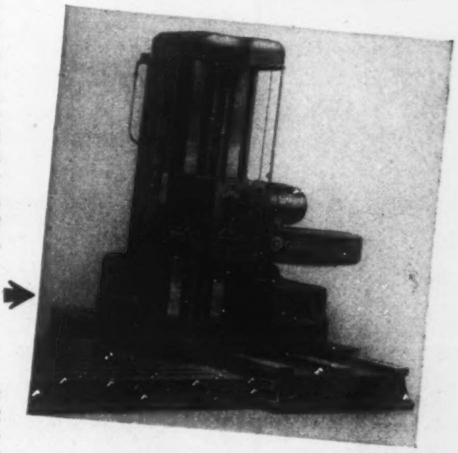
GIDDINGS & LEWIS MACHINE TOOL CO.'S BORING, DRILLING & MILLING MACHINE.

Cone-Drives are used on this as well as other G & L machines for smooth, accurate transfer of power in less space than otherwise possible.



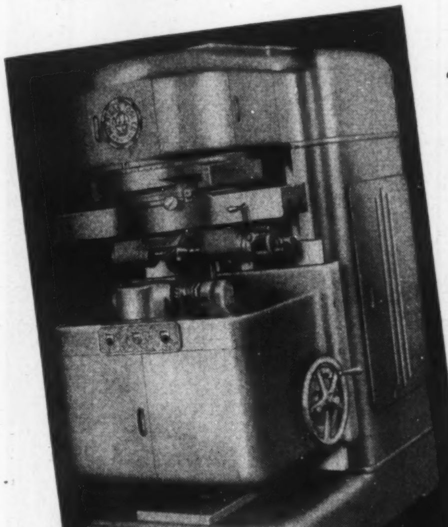
GISHOLT MACHINE COMPANY'S 50-TON 180-HP TURN MILL.

Roughs all rod bearings on a crankshaft from the forging every 2 minutes. The six 24" OD—78 rpm cutters are individually driven from 25 hp motors through 25:1, 10" C.D. Cone-Drives at 445 SFPM. This drive not only transmits high power smoothly but saves considerable space. Two 4" and two 5" C.D. (No. 7415) Cone-Drives rotate the work spindle smoothly at 1 rpm. The 5" Cone-Drives are driven by 2 pinions, one on each side of the gear, arranged so as to eliminate backlash.



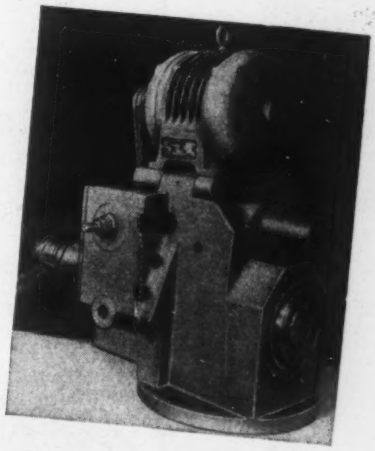
G. A. GRAY CO.'S 36 TON HORIZONTAL BORING, DRILLING & MILLING MACHINE.

7½" C.D. Cone-Drives feed the column smoothly along the runway at ½" to 120" per minute to a micro-jogging accuracy of 0.00025". Gears are self-locking for climb milling conditions, make for compactness by saving space.



MICHIGAN TOOL'S NEW "3-WAY" UNDERPASS GEAR FINISHER.

Faster gear finishing by *any* of 3 methods (selected at will) plus of course real smoothness and accuracy through Cone-Drives to the high speed cutters.



SHEFFIELD CORPORATION'S GEAR CHAMFERING MACHINES.

With Cone-Drive geared heads "for greater accuracy, less chance of backlash, more tooth-to-tooth contact and higher gear strength."

Did you See them at the Machine Tool Show

plus numerous other new Cone-Drive operated machines.

CONE-DRIVE DIVISION

MICHIGAN TOOL COMPANY
7171 E. McNichols Road, Detroit 12, U. S. A.

partners in creating

● "The impossible takes a little longer"... this is one way of saying that the draftsman lets no out-worn conceptions restrict his creative ideas. Yet without his specialized technique for expressing ideas on paper, the designs he creates could scarcely be turned into substance. As the draftsman relies on his own hands and eyes, he calls likewise on his drafting instruments to serve him functionally. So integral a part of his technique do they become, they are virtually his partners in creating.

For 80 years Keuffel & Esser drafting equipment and materials have been partners, in this sense, in creating the greatness of America, in making possible our fleets of ships, our skyscrapers, our overwhelming weight of armor on the battlefield . . . So universally is K & E equipment used, it is self-evident that every engineering project of any magnitude has been completed with the help of K & E. Could you wish any surer guidance than this in the selection of your own "drafting partners"?

Because of their balance, smooth action and responsiveness to your hand, you will find that using MINUSA* Drawing Instruments is almost as natural as breathing. Their legs are round and tapered, without the harsh feel of sharp corners. Joints are firm, snugly fitted, and satin-smooth in operation. Yet these instruments are strong and durable, for their precision will outlast years of continuous use. For complete data on MINUSA* Drawing Instruments, write on your letterhead to Keuffel & Esser Co., Hoboken, N. J.

*REG. U. S. PAT. OFF.

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Drafting, Reproduction, Surveying Equipment and Materials. Slide Rules, Measuring Tapes.
... the world's mightiest fleet
... speediest tanks
... tallest skyscrapers

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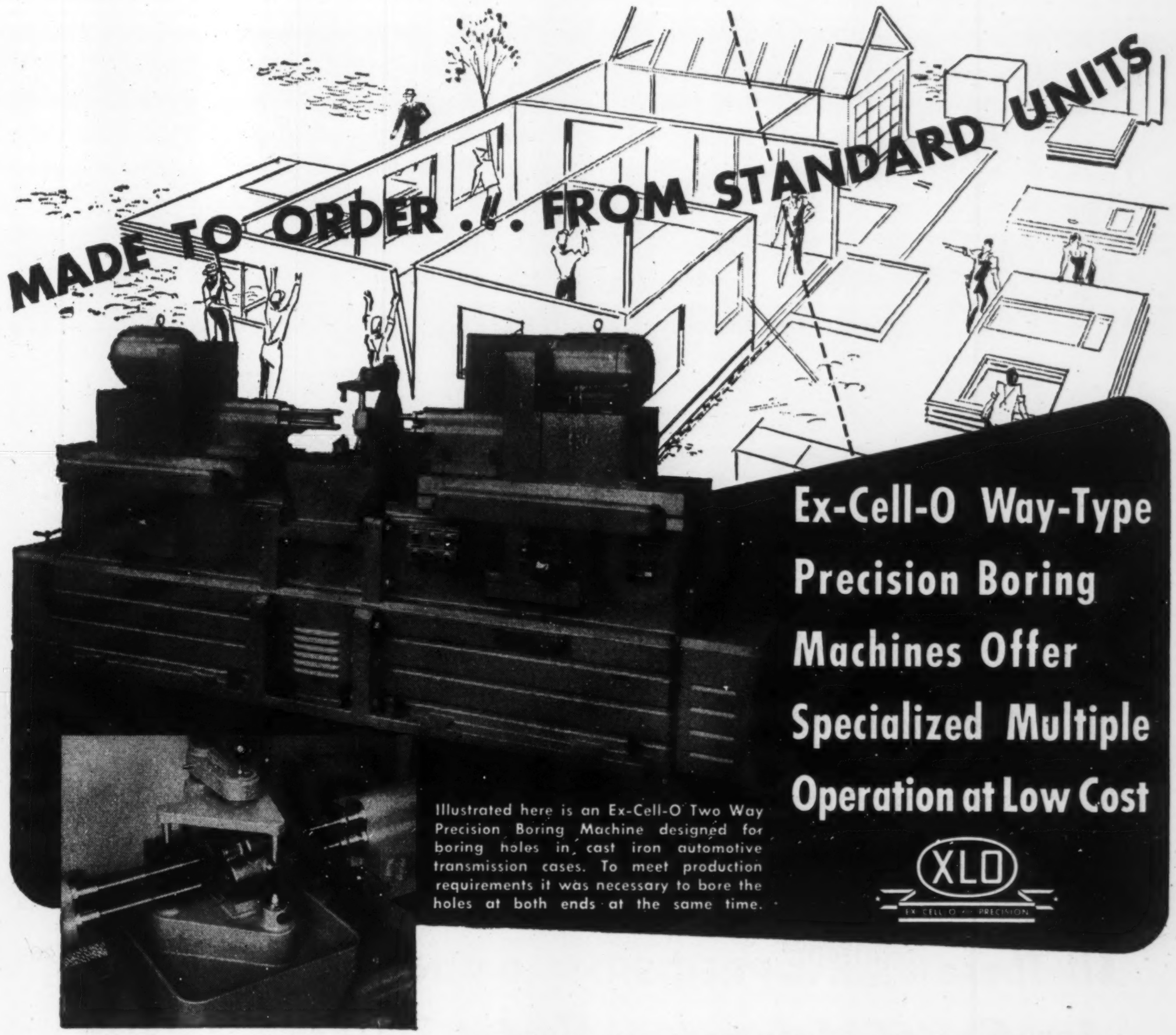
MADE TO ORDER . . . FROM STANDARD UNITS



Ex-Cell-O Way-Type Precision Boring Machines Offer Specialized Multiple Operation at Low Cost

Illustrated here is an Ex-Cell-O Two Way Precision Boring Machine designed for boring holes in cast iron automotive transmission cases. To meet production requirements it was necessary to bore the holes at both ends at the same time.

Above: Special cluster spindles are required here because of close center distances of bored holes. Because boring bars at left are long and slender the ends are further lengthened to engage pilot bushings in the fixture.

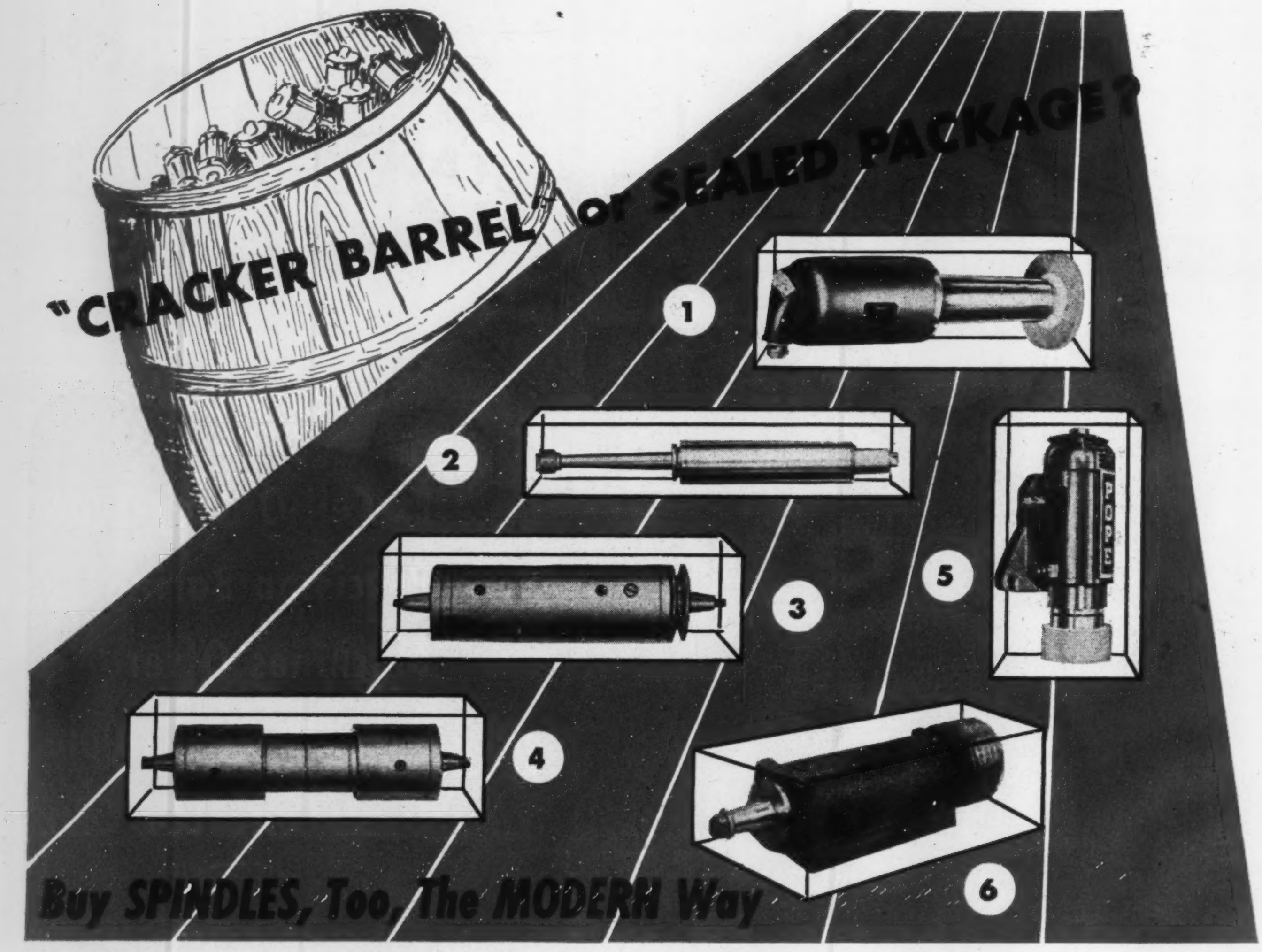
Ex-Cell-O Way machines are made to order for work like that illustrated here. They are built up from standard way units that can be operated simultaneously or in sequence as the work requires. Way machines do the work of special machines, but the use of standard units keeps the first cost low and, as production requirements change, the units may be rearranged to accommodate different work. Ex-Cell-O One Way Precision Boring Machines are especially suitable for heavy or awkward work. Two Way Machines accommodate awkward and long work pieces and save time by boring from both sides simultaneously. Three and Four Way Machines are particularly suitable for boring holes perpendicular to one another. An important feature of Way Machines is that multiple operations are performed from the same work locating points, with only one handling of the parts.

machine tools mean high production . . . high production means low unit cost . . . low unit cost means a higher living standard for everyone!
47—29

EX-CELL-O CORPORATION

**DETROIT 6
MICHIGAN**

MANUFACTURERS OF PRECISION MACHINE TOOLS • CONTINENTAL CUTTING TOOLS • MISCELLANEOUS PRODUCTION PARTS • FUEL INJECTION EQUIPMENT • RAILROAD PINS AND BUSHINGS • DRILL JIG BUSHINGS • PURE-PAK PAPER MILK BOTTLE MACHINES


"CRACKER BARREL" or SEALED PACKAGE?
1
2
3
4
5
6
POPE
Buy SPINDLES, Too, The MODERN Way

All These POPE PRECISION GRINDING SPINDLES Are *Sealed Lubrication, Sealed Package* Spindles

No. 1 is a POPE 6" x 18" Surface Grinder Spindle with *sealed-in* 1 HP motor and SKF double row, roller bearings. It produces superfine surface finishes and has the rugged ability to rough off surplus metal fast. Ask for Data Sheet No. 12.

No. 2 is an Internal Grinding Spindle — one of a wide range of sizes and speeds up to 35000 RPM. It produces accurate sized, better finished holes. Ask for Catalog No. 56.

No. 3 is a Tool and Cutter Grinder Spindle for Vee belt drive up to 6000 RPM. It fits standard grinders. Name your cutter and tool grinder and we'll send you an outline drawing.

No. 4 is a Double-Ended Tool and Cutter Grinder Spindle, belt driven with twin pulleys for two speeds from step pulley on motor. Speeds up to 6000 RPM. Fits standard grinders. Name your cutter and tool grinder and we'll send you an outline drawing.

No. 5 is a Surface Grinder and Boring Mill Spindle. It comes with 3, 5 or 10 HP motor running at 1200, 1800 or 3600 RPM. Ask for Data Sheet Nos. 16, 17, 18, 19.

No. 6 is a Wheel Head for special grinding, boring and other operations requiring from ¼ to 50 HP and speeds to suit your needs. Tell us your requirements.

POPE designs and builds special motorized Spindles in sizes from ¼ HP to 50 HP, with standard or high cycles, for speeds up to 54,000 RPM.

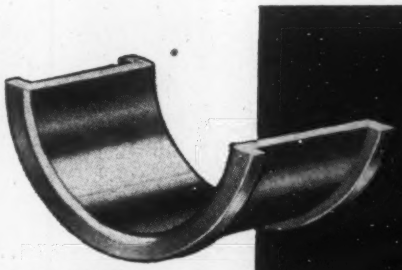
These Modern, Sealed Package Spindles Are Now Available For Quick Delivery

No. 46

POPE

TRADE MARK REG. U.S. PAT. OFF.

POPE MACHINERY CORPORATION
ESTABLISHED 1920
261 RIVER STREET • HAVERHILL, MASSACHUSETTS
BUILDERS OF PRECISION SPINDLES

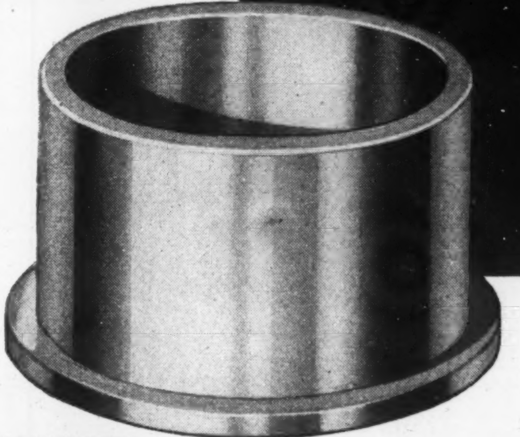


4" DIAMETER

We are Specialists in

BIG *Sleeve Bearings*

AN ENTIRE MODERN PLANT DEVOTED TO THEIR PRODUCTION: UP TO 27½" O. D.



6" DIAMETER

- *Steel, cast-iron or centrifugally cast bronze backs with tin or lead-base babbitt linings*
- *Solid Aluminum-tin alloy (AT-7)*
- *Plain: Single and Double-flanged; Halves or Full-round; Precision or Semi-Precision*
- *Any quantity, large or small*
- *Prompt delivery assured*

25" DIA.

Your large sleeve bearing and bushing requirements—from 6" to 27½" O.D.—can be supplied promptly from our big-bearing plant.* This plant is devoted *exclusively* to the manufacture of large bearings and bushings and has the modern machines and skilled manpower to produce according to your cost requirements. Extensive research and engineering facilities are available—without obligation—for consultation on materials and designs. *Your inquiry is invited.*

FEDERAL-MOGUL CORPORATION
11045 Shoemaker, Detroit 13, Michigan

** Smaller sizes are available from our six other plants—each specializing in a specific range of size and alloy combinations.*

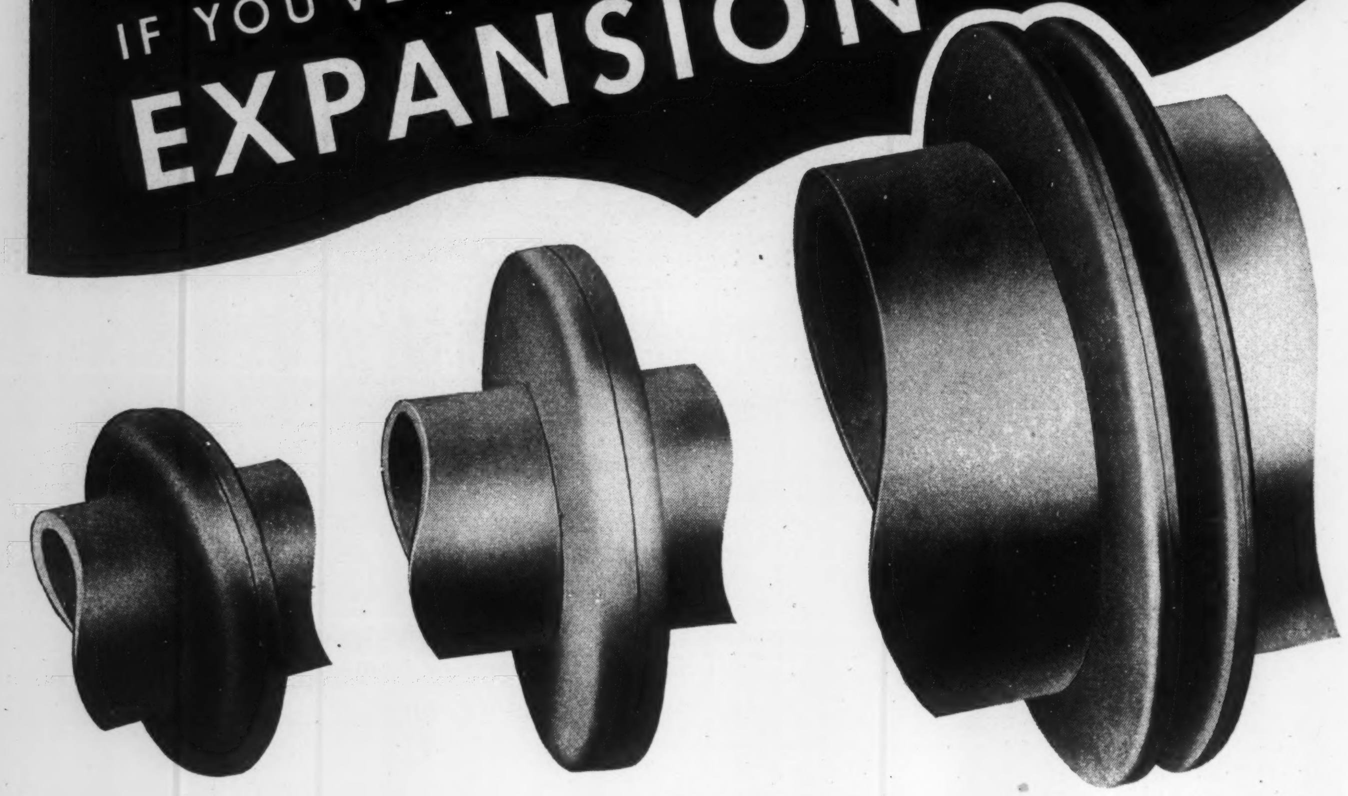
Power goes to work through

FEDERAL-MOGUL

Silent FEDERAL Mogul **SLEEVE BEARINGS**

IF YOU'VE A PROBLEM OF

EXPANSION



. . . let Lukens Head-Shapes handle it

Each of these expansion joints started out as a Lukens Head-Shape. Welded flange to flange, in single or multiple bellows, these head-shapes provide the flexibility required because of longitudinal expansion and contraction.

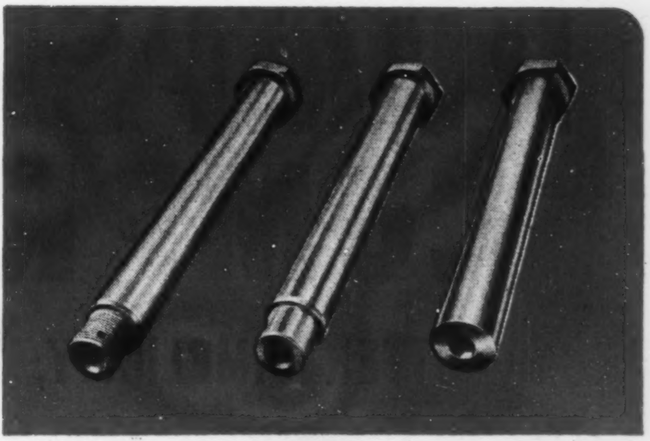
You realize several important economies by starting with Lukens Head-Shapes: The fabricating shop receives a semifinished product, nearly ready for the welder. You need no expensive equipment to form the plate. And think of the time and labor you save!

Because head-shapes are *plate* products, the metal is sound, uniform in structure and dependable. Parts can be made lighter in weight. Products perform better and last longer.

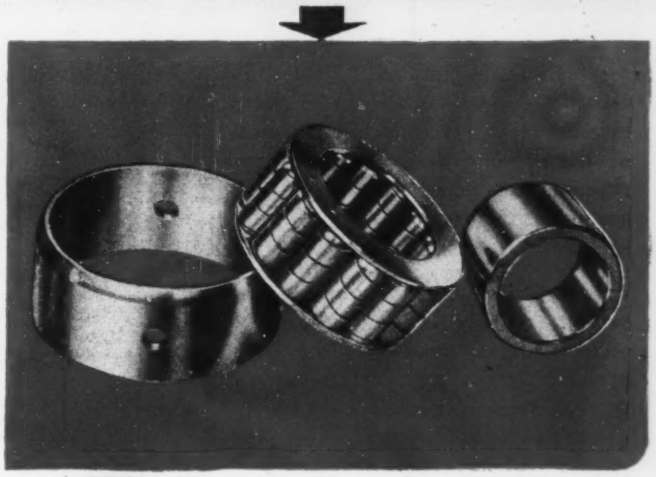
If you're wondering about ways of expanding your production at a minimum of expense, figure on using Lukens Head-Shapes for a "head start". Our engineers welcome the opportunity to help you adapt them to your designs. Write Lukens Steel Company, 418 Lukens Building, Coatesville, Pennsylvania.

LUKENS

HEADS ★ **FOUR INCHES TO OVER EIGHTEEN FEET IN DIAMETER**



TURNED OUT OF TUBING AT A SAVING



These and hundreds of other different hollow machined parts are now being turned out of easy-to-work, dimensionally accurate B&W Mechanical Tubing . . . faster, more uniformly, in fewer operations and with less scrap loss than from solid stock. Have you investigated the advantages of switching to tubing?

B&W can help you . . . in two important ways: By sharing its broad and diversified experience in applying tubing — both Seamless and Welded — to mechanical uses with your design and production staff and by supplying *either* kind of tubing of the proper analysis, size, gauge, temper and finish for making any part . . . at a saving in time, cost and material.

A FEW OF THE MANY USES FOR B&W MECHANICAL TUBING

AUTOMOBILE AXLE HOUSINGS • REFRIGERATOR TUBING • FIRE EXTINGUISHERS • FLUE TUBES FOR WATER HEATERS • METAL FURNITURE • SURVEYING INSTRUMENTS • AGRICULTURAL MACHINERY • ENGINE CYLINDER LINERS • TRACTOR PARTS, PINS AND BUSHINGS • PIPE COUPLINGS AND FITTINGS • BUS SEATS AND HAND RAILS • AIR COMPRESSORS

TA-1420M

Seamless and Welded Tubular Products in a full range of Carbon, Alloy, and Stainless Steels for All Pressure and Mechanical Applications.

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Other B&W Products

THE BABCOCK & WILCOX CO.
85 LIBERTY STREET • NEW YORK 6, N. Y.

Stationary and Marine Boilers . . . Boiler Components . . . Pulverizers . . . Fuel Burning Equipment . . . Refractories . . . Chemical Recovery Units . . . Process Equipment . . . Alloy Castings.

BABCOCK & WILCOX
SEAMLESS & WELDED TUBES
THE BABCOCK & WILCOX TUBE COMPANY
GENERAL OFFICES: BEAVER FALLS, PA.
PLANTS: BEAVER FALLS, PA. AND ALLIANCE, OHIO.

PUMPS-MOTORS COMPRESSORS

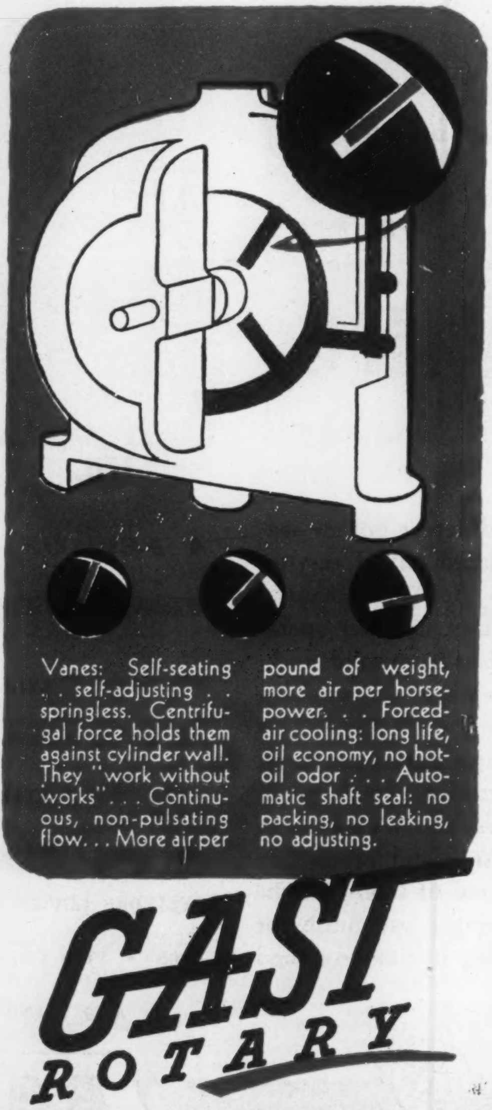
UTTER SIMPLICITY, MASTERFULLY DEVELOPED

. . . the Gast Vacuum Pumps (to 28 in.), Compressors (to 30 lbs.), and Air Motors (to 1 h.p.)

Gast design shows what can be done by working *WITH* principles instead of settling one design problem by creating two new ones. And Gast manufacturing exemplifies the old truism about doing one thing well.

The result is a line of rightly-priced, service-free vacuum pumps, compressors and air motors of the kind manufacturers appreciate having as original equipment on their machines, and users like to find there.

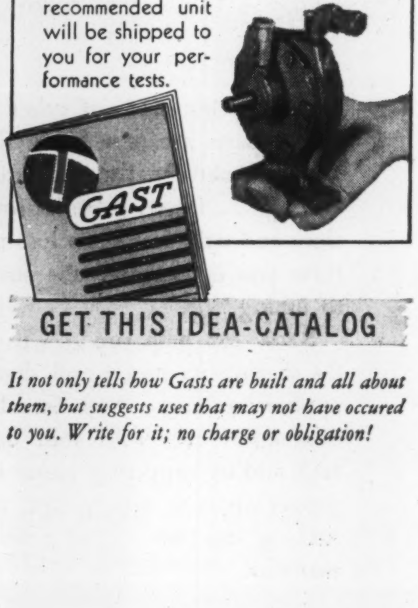
If you do not use air power but *COULD*, to better advantage, or if you already use air power, Gast, surely, will prove to be your better selection from both the original cost and the performance-and-maintenance standpoints, as it has for increasing scores of makers of a wide variety of machines and equipment. Avail yourself of Gast application experience, have Gast simplicity and faithful performance working for you ever after! GAST MANUFACTURING CORPORATION. 107 Hinkley St., Benton Harbor, Mich.



Vanes: Self-seating . . self-adjusting . . springless. Centrifugal force holds them against cylinder wall. They "work without works". . . Continuous, non-pulsating flow. . . More air per pound of weight, more air per horsepower. . . Forced-air cooling: long life, oil economy, no hot-oil odor . . . Automatic shaft seal: no packing, no leaking, no adjusting.

ENGINEERING TEST OFFER —So You Can SEE IF YOU'RE MISSING SOMETHING!

Simply write our Engineering Department and explain the operation you think air might handle, or describe the job air is already doing for you. Our Engineering Department will study your problem, select or design a Gast unit to do the specified work at less cost or at greater efficiency or both. Then, **without cost** or obligation, the recommended unit will be shipped to you for your performance tests.

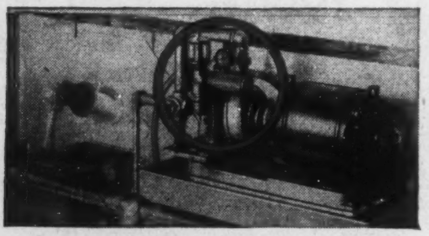


GET THIS IDEA-CATALOG

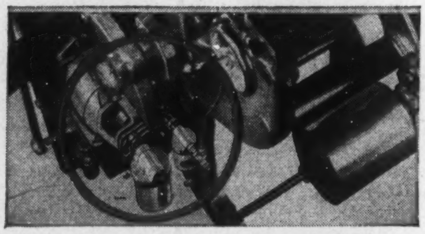
It not only tells how Gasts are built and all about them, but suggests uses that may not have occured to you. Write for it; no charge or obligation!

GAST ROTARY

VACUUM PUMPS·AIR COMPRESSORS·AIR MOTORS



Supplying Air to Industrial Oil Burner

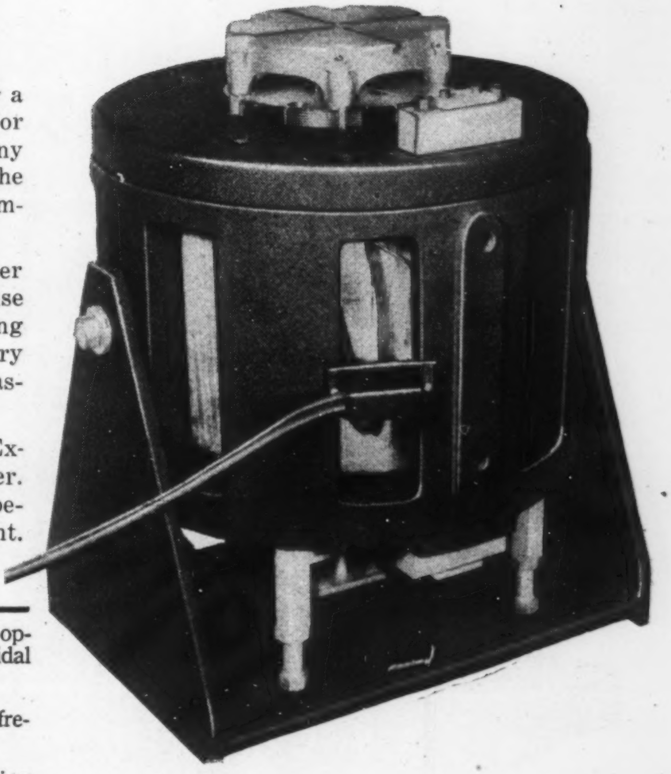


Vacuum Service on a Labeling Machine

8-1413-8

HOW TO USE VIBRATION
to shake the "bugs" out of your product

This MB Vibration-Exciter will do it for you . . . quickly . . . efficiently!



THERE ARE many ways you can put vibration to work for a better product. Use it for quality-control, or inspection, for example. With this MB Exciter, you can shake-test many electrical and mechanical products for defects—right on the production line. Or you can connect it to power-driven assemblies to locate rattles and hums—*and their sources.*

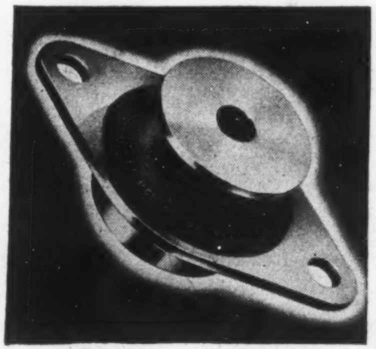
As an aid to research, this shaker is hard to beat for sheer usefulness. It reproduces vibrational effects of *years* of use within *hours!* Shake testing also shows whether operating conditions produce destructive resonance in any part. In every case, the "cure" is then easier, more accurate—and you assure a quieter, safer, longer-lasting product.

Many plants and laboratories are now using the MB Exciter for just such purposes. It pays for itself many times over. Why not write us about your "tough nut"? As vibration specialists, MB can show you how to crack it with this equipment.

PARTIAL TECHNICAL DATA

- Wide frequency range—3 to 500 cps.
- Output—up to 200 pounds peak value.
- Power—1500 v.a. maximum continuous.
- Amplitude—1-inch total excursion.
- Waveform—electrodynamic operation produces pure sinusoidal motion.
- Electrical adjustments—for frequency, force and amplitude.
- Smaller sizes available having wider frequency ranges.

IT'S EASIER DESIGNING WITH MB ISOMODE* MOUNTINGS



1. **THEY ABSORB VIBRATION EQUALLY WELL IN ALL DIRECTIONS,** so they control not only vertical, but troublesome horizontal and rocking motions as well.
2. **THEY'RE NON-DIRECTIONAL.** With an equal spring rate in all directions, they mount at any angle, giving you extra design freedom.
3. **THEY HAVE HIGH LOAD-CAPACITY IN COMPACT SIZES,** saving you space and weight.
4. **THEY HAVE PLENTY OF RUBBER FOR SOFTNESS,** yet are perfectly stable and safely self-snubbing.

Together with the tremendously simplified MB Design Method for positioning them, they offer you performance that makes satisfied customers. Send your vibration problems to MB if you want results. Our engineers are always ready to assist you.

*Trade Mark Reg. U. S. Pat. Off.

SEND FOR FREE BULLETINS

Bulletin on "Vibration Testing Technique." No. 4-5 provides helpful design information on mountings. Reprint of technical Paper describes Isomode Simplified Design Method. Write Dept. C3.

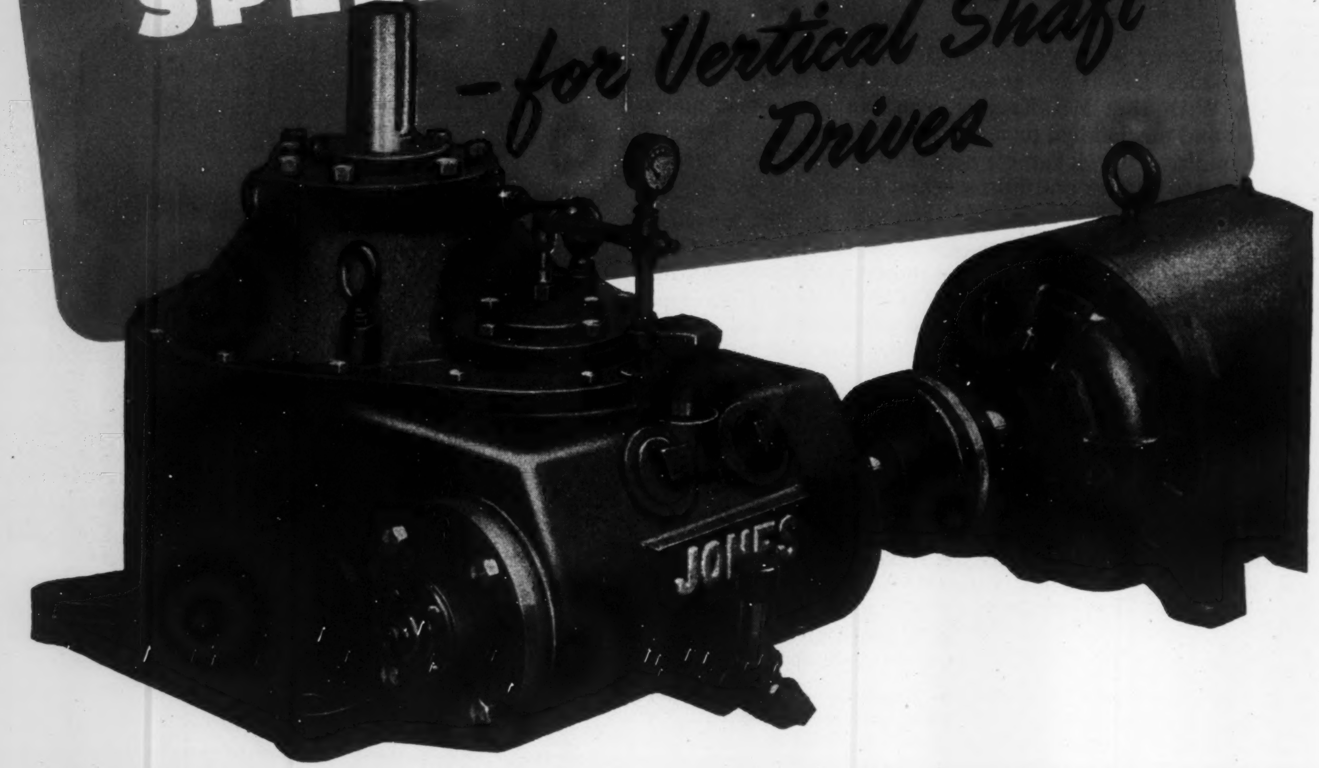
THE
MB MANUFACTURING COMPANY, INC.
1060 State Street
New Haven 11, Conn.
VIBRATION ISOLATOR UNITS • VIBRATION TEST EQUIPMENT

VIBRATION DIVISION

Jones

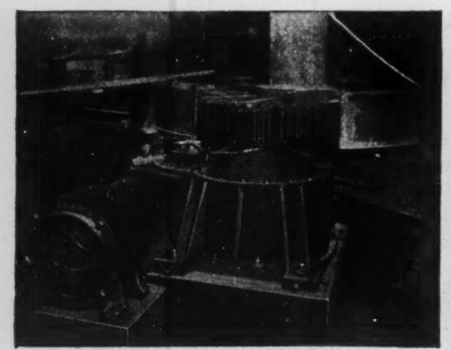
WORM-HELICAL SPEED REDUCERS

—for Vertical Shaft Drives

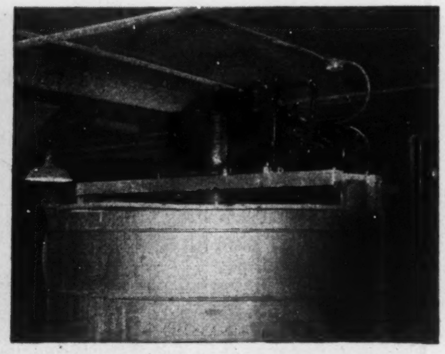


THESE machines fill a long felt need for double reduction units of the fully enclosed type to be used for agitators, mixers, ore roasters, bending rolls, etc., requiring a vertical shaft drive. Built in standard ratios in various types of assemblies ranging from 40 to 1 to 250 to 1 for all common motor speeds and a wide range of horsepower ratings.

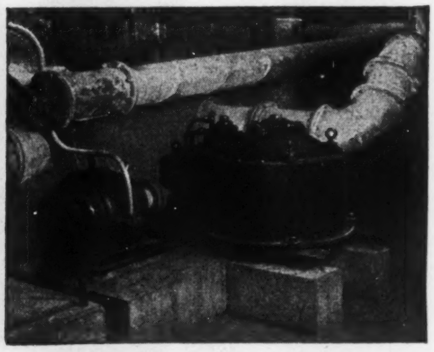
Jones Bulletin No. 75 covers complete details on these Worm-Helical Speed Reducers, with rating tables, dimension diagrams, torque charts and other application information. We shall be pleased to send you a copy.



● Jones Worm-Helical Speed Reducer on ore roaster with section of dust guard removed to show final gear reduction.



● Jones Worm-Helical Speed Reducer driving a lacquer agitator. A simple design prevents leakage of oil along the vertical low speed shaft.



● Jones Worm-Helical Speed Reducer on a paper mill agitator drive.

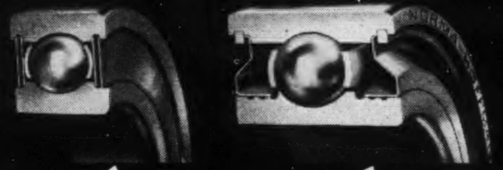
W. A. JONES FOUNDRY & MACHINE CO., 4413 Roosevelt Road, Chicago 24, Illinois

"If it isn't Wide Enough It isn't Good Enough"

...TO MEET TODAY'S PROBLEMS

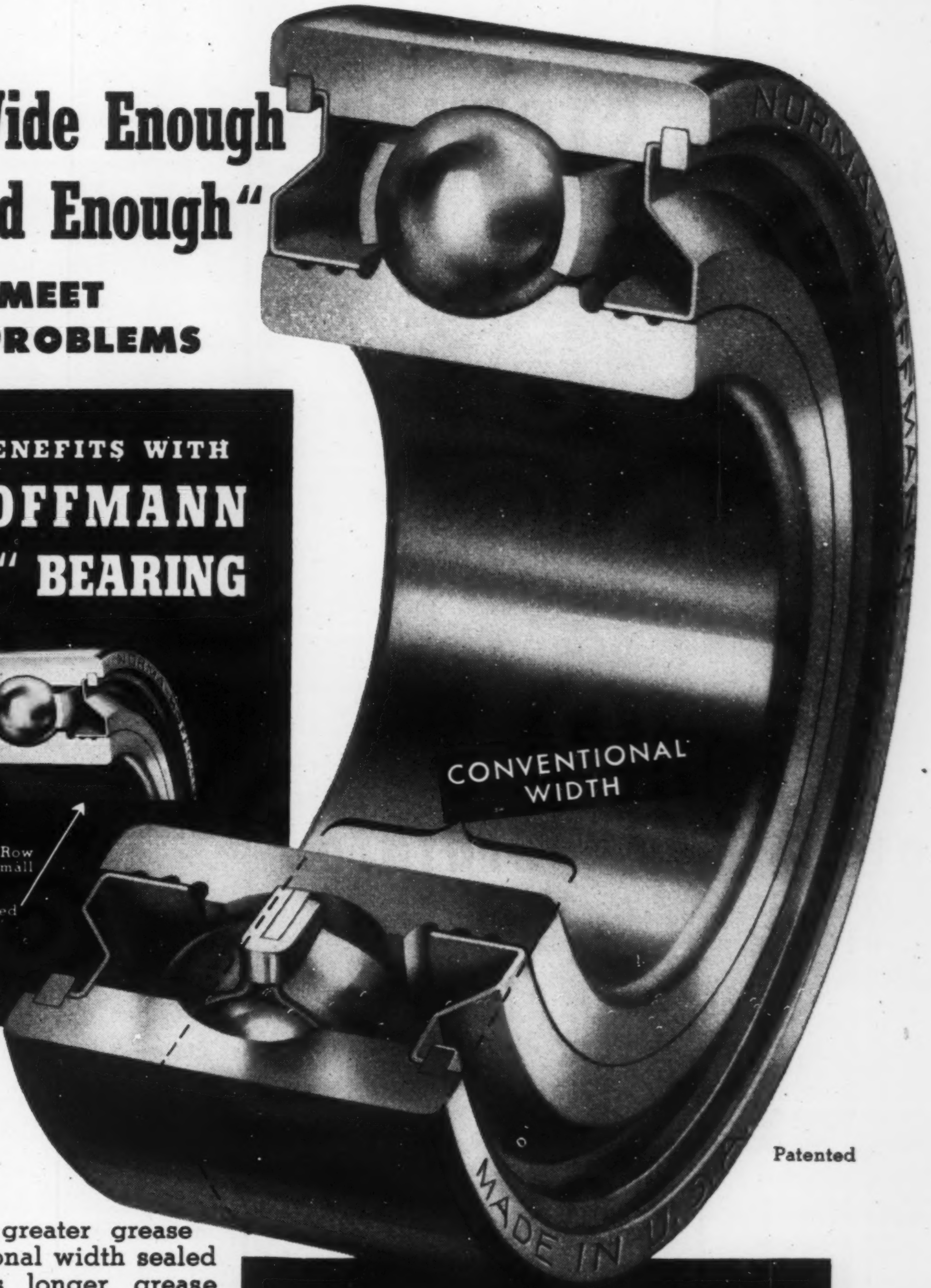
GET 3 DESIGN BENEFITS WITH

NORMA-HOFFMANN "CARTRIDGE" BEARING



CONVENTIONAL Single Row Width sealed bearing has small grease capacity.

NORMA-HOFFMANN patented double row width "Cartridge" Bearing has 100% greater grease capacity.



Patented

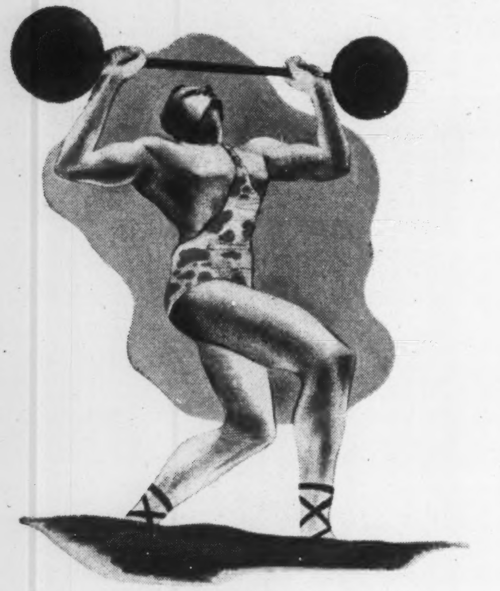
Here's What You Get

1. **Longer Life** A 100% greater grease capacity than conventional width sealed bearings. This means longer grease life... longer periods between relubrication—because a large volume of grease does not oxidize or dry out as readily as a thin film of grease.
2. **Greater Contact Area** 43% to 85% greater contact area between shaft and bearing bore and between housing and bearing O.D., as compared to conventional width bearing. This eliminates need for locknuts and results in greater shaft strength as it is unnecessary to cut locknut threads. Slippage and peening are also prevented.
3. **Full Load Carrying Capacity** Unlike many other sealed bearings, *full size* balls are used; hence, there is no reduction in load carrying capacity.

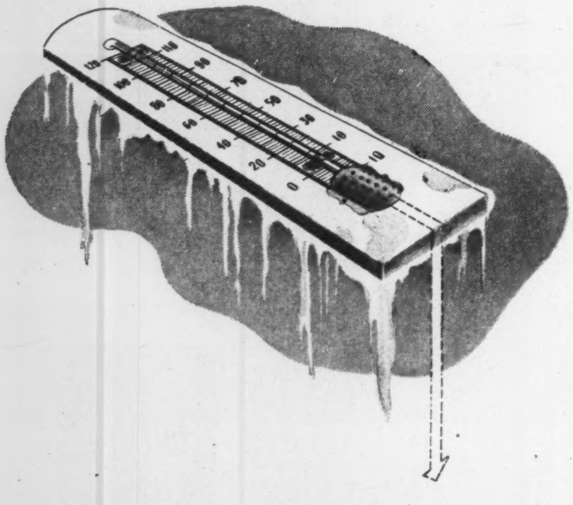
America's No. 1 SEALED BEARING by NORMA-HOFFMANN

NORMA-HOFFMANN BEARINGS CORPORATION,
STAMFORD, CONNECTICUT
FIELD OFFICES: New York, Chicago, Cleveland, Detroit, Pittsburgh, Cincinnati, Los Angeles, San Francisco, Seattle, Phoenix

for HIGH STRENGTH



at low temperatures



REVERE COPPER and COPPER ALLOYS

● Revere Copper and copper-base alloys are a "natural" when dealing with applications involving subnormal temperatures all the way down to liquid oxygen (-306°F.) and below.

Copper and its alloys possess the valuable characteristics of becoming increasingly stronger, the lower the temperature, *with no attendant loss of ductility,* and *with no tendency toward brittleness or "notch-impact" sensitivity.*

For example, note the rise in strength, ductility *and* resistance to impact for two copper and brass alloys:

Alloy	Temp. °F.	Tensile Strength, p.s.i.	Elongation % in 2 in.	Impact Resistance, Kg-m per sq. cm.
Electrolytic				
Tough Pitch	68	58,700	8.4	6.6
Copper (Cold Rolled Strip)	-295	64,800	11.2	7.4
Yellow Brass	73	85,400	6.3	8.1
(Cold Rolled Strip)	-295	102,900	10.1	9.4

Other Revere Alloys, such as Herculoy (High-Silicon Bronze, A), show similar improvement in these important mechanical properties.

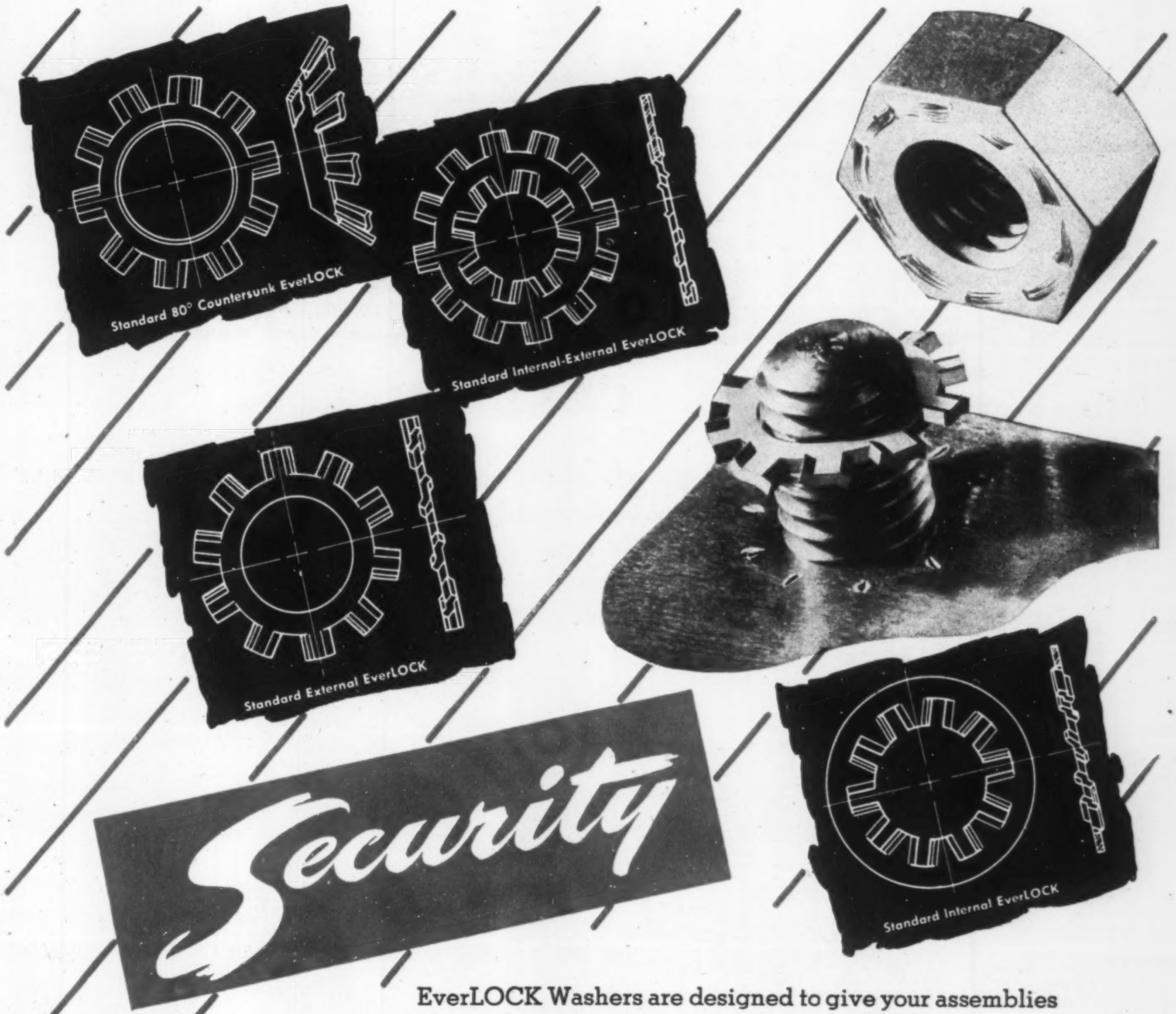
If you make or are contemplating the manufacture of liquid oxygen equipment, you will be playing safe to specify copper-base alloys. Get in touch with Revere for full information on the low-temperature physical characteristics of Revere metals.

• • •

REVERE

COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801
230 Park Avenue, New York 17, New York
Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y.
Sales Offices in Principal Cities. Distributors Everywhere.


Standard 80° Countersunk EverLOCK
Standard Internal-External EverLOCK
Standard External EverLOCK
Security
Standard Internal EverLOCK

EverLOCK Washers are designed to give your assemblies extra *security* under vibration, expansion, contraction, or strain. Alternating chisel edges—forced into the contiguous faces of both work and nut by perfect spring tension—provide 2-way locking action. Four standard types meet most lock washer needs.

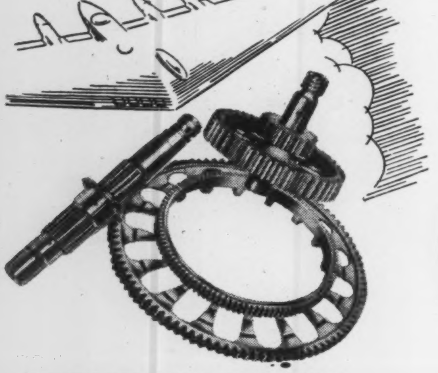
Other EverLOCK advantages include: (1) Fast, easy application that cuts assembly time and cost, (2) Automatic elimination of all hazards of stretched bolts or distortion of threaded parts.

Wire, phone or mail your orders today.

Ever LOCK WASHERS

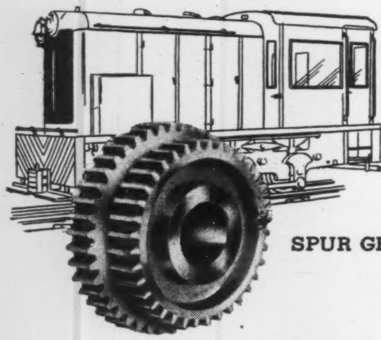
THE WASHER THAT HAS THE EDGE

THOMPSON-BREMER & CO. 1636 W. HUBBARD ST., CHICAGO 22, ILL.

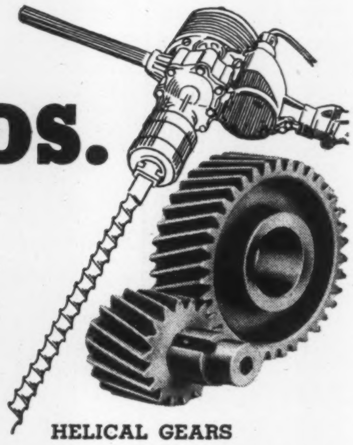


AIRCRAFT QUALITY GEARS

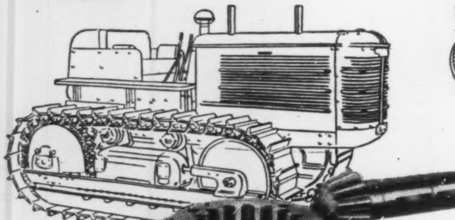
WHATEVER YOUR NEEDS IN GEARS CALL ON FOOTE BROS.



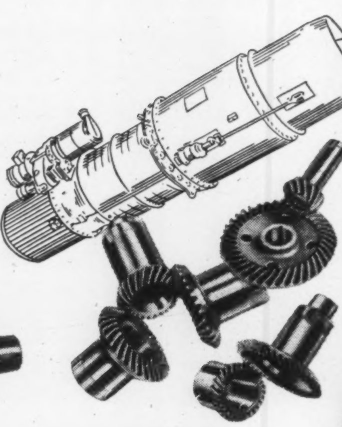
SPUR GEARS



HELICAL GEARS



BEVEL GEARS



SPIRAL BEVEL GEARS

LARGE GEARS

SPUR GEAR ILLUSTRATED 21 FT. DIAM.

Faced with problems of designing machines to operate at high speed and greater efficiency many manufacturers are finding an answer in gears produced by Foote Bros. These high quality gears also assure lower noise level and greater compactness, permitting new refinement in machine design.

Foote Bros. facilities include the most modern production machinery backed by nearly a century of experience in gear design and manufacture.

Regardless of whether you need high precision gears to operate at extremely high speed or giants twenty feet in diameter to turn a cement kiln . . . regardless of whether you require spur, helical, worm or bevel gears for machine tools, diesel engines, tractor transmissions, mining machinery, printing presses or any one of a thousand applications . . . Foote Bros. has the engineering staff, plant facilities and manpower to produce them.

Call your Foote Bros. representative or write for further information . . .

* * *

A new folder showing Foote Bros. facilities and containing a valuable reference table on gear types is available. Write for your copy.

FOOTE BROS. GEAR AND MACHINE CORPORATION, Dept. O, 4545 S. Western Blvd., Chicago 9, Ill.

WORM GEARS

FOOTE BROS.

Better Power Transmission Through Better Gears

What has Star got?

Before you pick any motor to power your product we'd like to submit 3 teasers—

". . . and I know 'em all!"

Why did a famous maker of Materials Handling Equipment* not long ago say—"There isn't a Brake Motor built that can touch that Star, and I know 'em all"?

". . . you like 'em tough"

Why did one of the world's biggest makers of Machine Tools* recently choose Star to work with on a tough application problem?

". . . laying it in your lap"

Why did a noted Dairy Machinery company* pick Star to develop a unique heavy duty motor for their new machine?

(**Name on request*)

We needn't tell you that buyers like these three are motor-wise, and hard-boiled in their determination to obtain the most satisfactory solution to powering their products. . . .

And we needn't tell you that we have engineering brains second to none, or that we have excellent production facilities. Without them, we could not get to first base. . . .

What, then, is the "something extra on the ball" we *must* have to lead such concerns to choose to work with Star on their new products?

You'll find it's Star's approach to a motor problem—a willingness to give your job "top billing". There's no stop-watch on the brains applied to your problem —and there are not so many problems that we can't apply our best brains to all.

That's why you, too, will choose wisely by making Star your "Motor Department". Our designing facilities can be placed at your command NOW, to solve any problems not covered by standard Star Motors, from ½ to 200 HP. Star Electric Motor Co., 200 Bloomfield Ave., Bloomfield, N. J.

STAR MOTORS

POWER PACKAGED AS YOU NEED IT

unit of energy

GEROTOR
HYDRAULIC

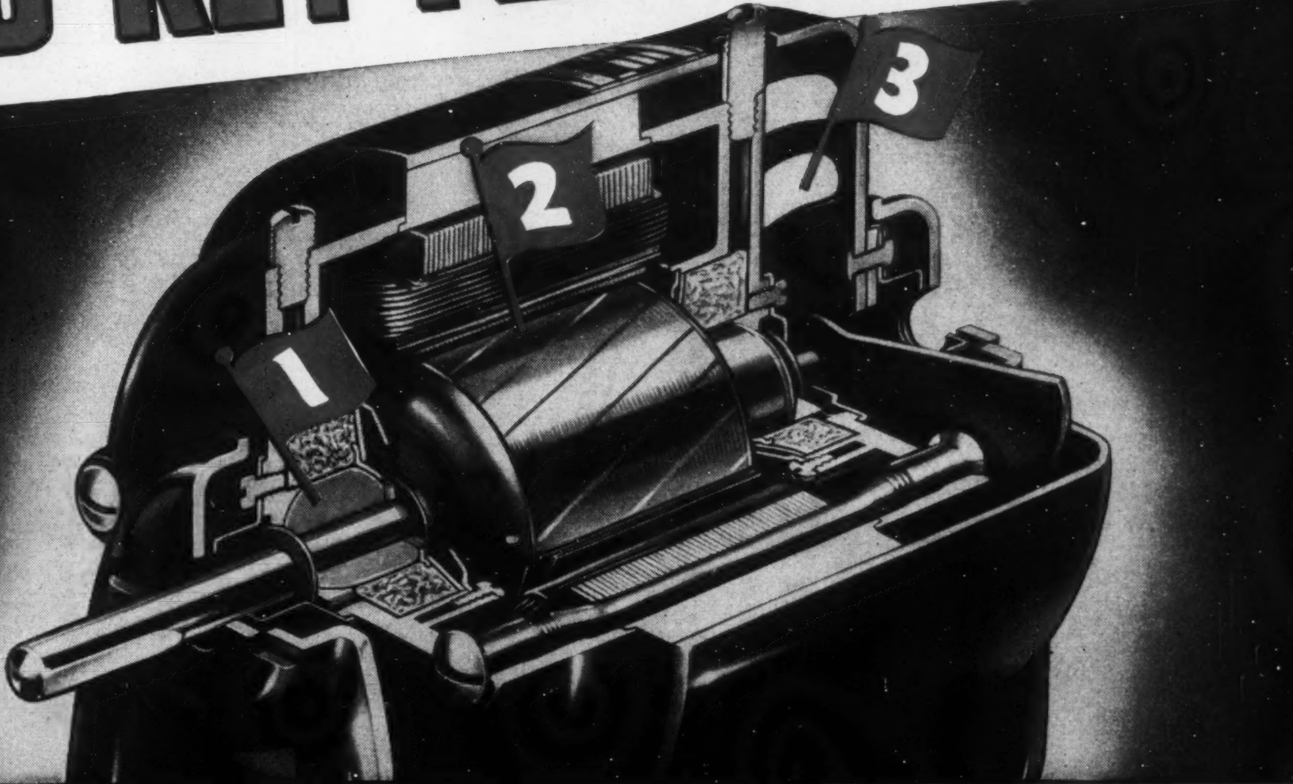
A unit of exceptional energy is the Gerotor Hydraulic Pump Unit . . . capable of delivering a steady oil flow at continuous pressures up to 1000 p.s.i. (1200 in some pump sizes). Models available for one or two hydraulic circuits . . . tank capacities from 4½ to 100 gallons. Each unit complete with Gerotor pump, tank, relief valve, gauges, filter, coupling and piping. Write for data on the specific application you have in mind. Gerotor May Corporation, Baltimore 3, Md.

GEROTOR

hydraulic pump units

hydraulic pumps, motors, valves and cylinders • air valves and cylinders

3 KEY FEATURES...



ASSURE LONG-LIFE IN 1/25th HP. A.C.

Redmond MICROMOTORS

1 **BROADLY SPACED BEARINGS,** individually fitted and with large capacity lubrication, provide solid footing for thousands of hours of steady service. Moving parts retain accurate alignment.

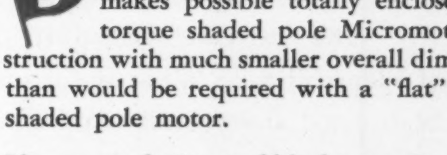
2 **FLUSH-WELD PRECISION SKEWED ROTOR** is the heart of every Redmond A.C. Micromotor. Here's maximum electrical conductivity and quiet operation. In this micro-balanced rotor there are no open slots to collect chips, dirt and dust.

3 **AIR-STREAM ENCLOSED COOLING** makes possible totally enclosed high torque shaded pole Micromotor construction with much smaller overall dimensions than would be required with a "flat" surface shaded pole motor.

If you need twenty-fifth horsepower 4-pole shaded pole motors for A.C. operation, check these fine Type "T" Micromotors. Other Redmond Micromotors are made in sizes from 1/150th up to 1/15th horsepower.

☆ *Expanded facilities. Prompt deliveries. Service before and after the sale.*

Redmond COMPANY, Inc.
MAIN OFFICES: Owosso, Michigan
EASTERN AREA SALES: 420 Lexington Ave., New York 17, N. Y.
PACIFIC COAST SALES: Redmond Company of Calif., Inc., 117 W. 9th St., Los Angeles 15, Calif.



Redmond facilities now total more than 5 acres floor area and 2000 employees.

REDMOND
REG. U. S. PAT. OFF.

Add: WHITNEY CHAIN
To: GOOD MACHINE DESIGN
Result: EFFICIENT, POSITIVE DRIVE
SIMPLE ADDITION
12+4=16

The extreme versatility and unusual adaptability of Whitney Chains to meet both usual and special requirements make them the experienced designer's choice for all types of applications from power transmission to material conveying.

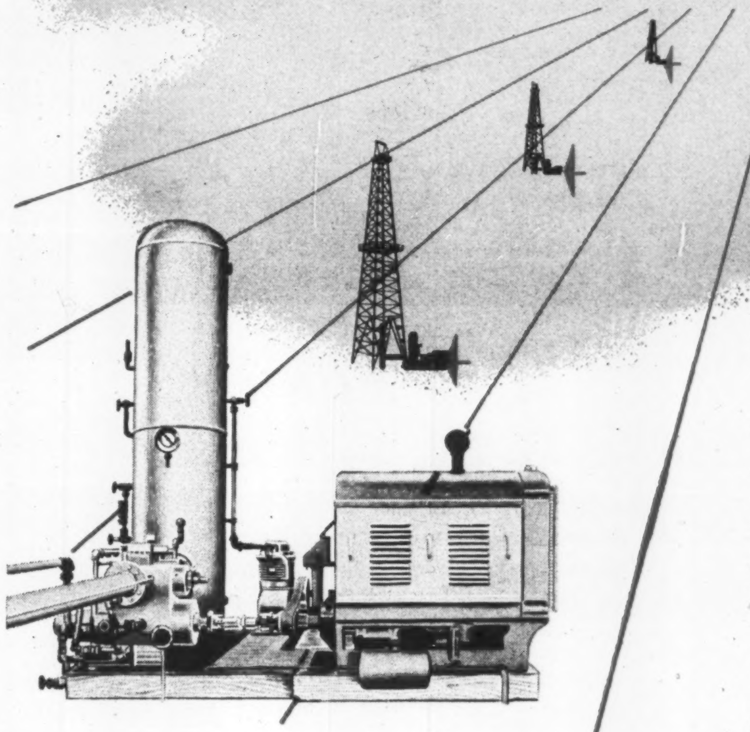
Whitney Chains . . . *the all-steel drives* . . . deliver *full* power without slippage. Their positive grip transmits constant, uniform speed. Tough and rugged, they give long-lived service with minimum maintenance.

Regardless of the application, you will find that it pays to *standardize* on Whitney Chains. And to complete your drives, the best combination is Whitney Chain plus Whitney Cut Tooth Sprockets. Write for complete information.

The Whitney Chain & Mfg. Co.
HARTFORD 2, CONNECTICUT

ISOLATED

CONTINUOUS—DEPENDABLE—UNATTENDED OPERATION WITH A DE LAVAL-IMO PUMP



When designing the Pelton Long-Stroke Hydraulic Jack, Pelton engineers required a pump that would operate continuously for long periods and maintain a constant flow at a steady pressure under a wide range of temperature ranges. Above all the pump had to be dependable—operate with infrequent service checks in isolated areas.

The De Laval-IMO was found to fit the job. Chosen by the Pelton Water Wheel Company engineers, the De Laval-IMO became an important part of the Hydraulic Jack; is helping to maintain Pelton's leadership of 65 years in the design and construction of hydraulic equipment by functioning smoothly with constant flow at even pressures despite wide temperature ranges.

This application of the De Laval-IMO pump illustrates one of the many recent IMO developments. Although we cannot predict all new developments, our experience with this new type of rotary pump enables us to offer you a complete pump engineering service.

Investigate the IMO

DE LAVAL STEAM TURBINE COMPANY, TRENTON 2, NEW JERSEY

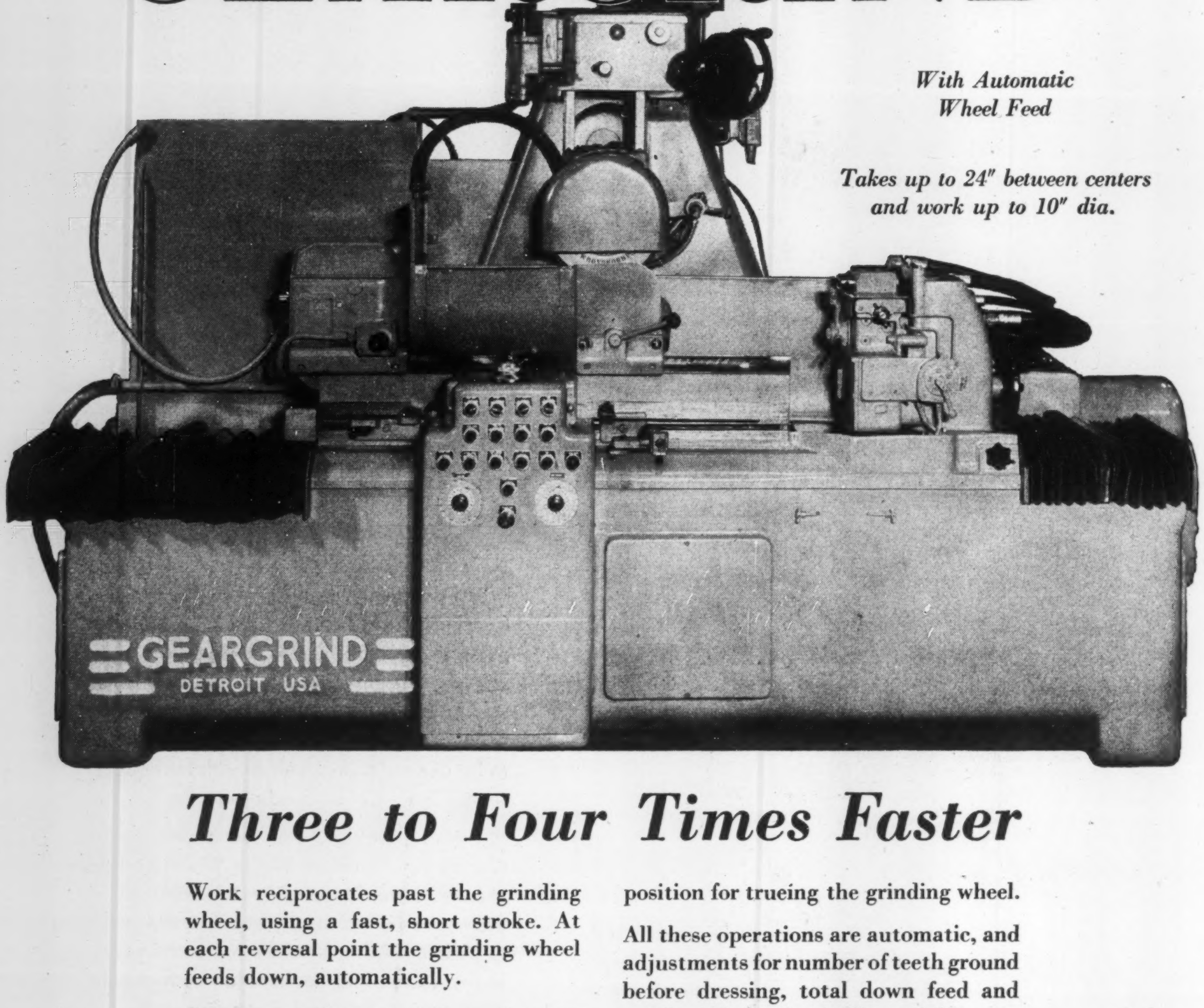
IMO Pump Division

Manufacturers of Turbines, Gears, Pumps and Blowers

I-148-C

Atlanta • Philadelphia • Charlotte • Pittsburgh • Cleveland • Rochester • Detroit • San Francisco • Chicago • New York • Boston • Denver • Edmonton
Helena • Houston • Kansas City • St. Paul • Los Angeles • Toronto • New Orleans • Seattle • Salt Lake City • Tulsa • Vancouver • Winnipeg • Washington, D.C.

The NEW
GEARGRIND



With Automatic
Wheel Feed

Takes up to 24" between centers
and work up to 10" dia.

Three to Four Times Faster

Work reciprocates past the grinding wheel, using a fast, short stroke. At each reversal point the grinding wheel feeds down, automatically.

Grinding continues on one tooth space until a "rough size" is reached, after which the work is indexed and the grinding wheel head re-set.

After a pre-set number of teeth have been "roughed out" the dresser moves into position for trueing the grinding wheel.

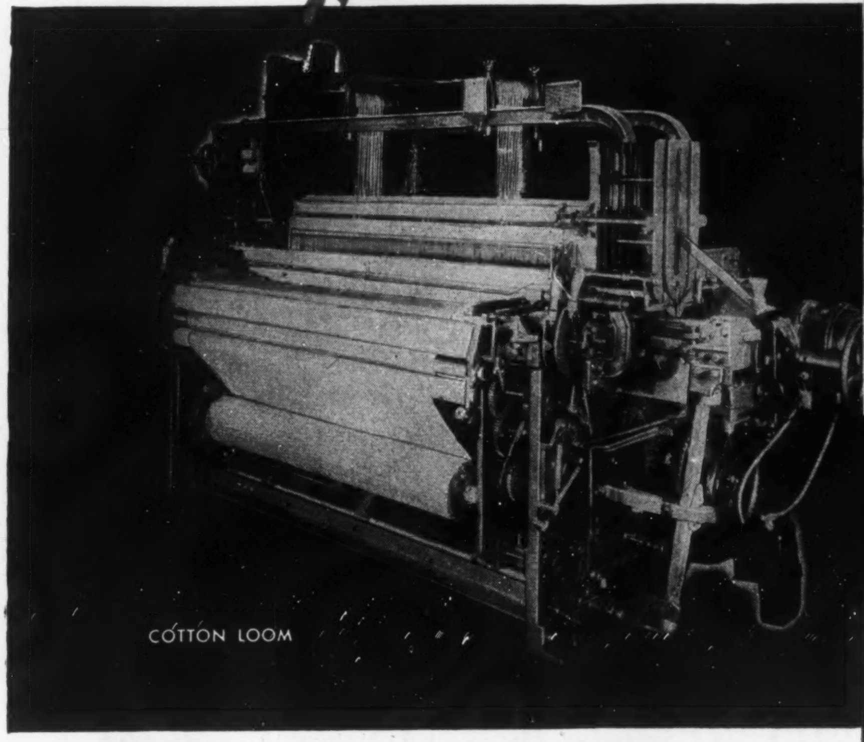
All these operations are automatic, and adjustments for number of teeth ground before dressing, total down feed and number of cuts is readily variable over a wide range.

Grinding by this new GEARGRIND method is done in ⅓ to ¼ of the time required by any previous gear grinding machine of comparable capacity.

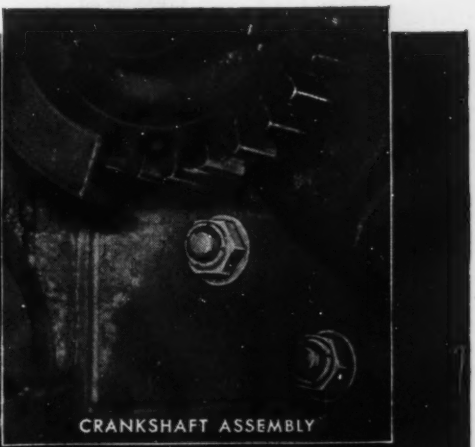
***WRITE** for complete information.*

The GEAR GRINDING
MACHINE COMPANY
DETROIT 11, MICH. U.S.A.

SELF-LOCKING *Protects Inaccessible Parts* AGAINST LOOSENING AND BREAKING



COTTON LOOM



CRANKSHAFT ASSEMBLY

The Red Elastic Collar protects prestressed or positioned settings against VIBRATION!

What happens when the inaccessible fasteners on the crankshaft assembly are loosened by the endless vibration built up by the distinct shock of the drive gears at pick and beat up? Mechanically, prestressed and positioned settings are changed, spilt-second, synchronized timing is upset, and loose parts wear beyond repair. This means costly repairs and unnecessary down time.

Production-wise, it means that uneven power delivery is causing such cloth defects as overshots, broken ends, pull-ins and mispicks.

Here's a suggestion to loom fixers. When repairs or adjustments make it necessary to remove an ordinary fastener, replace it with an ESNA Elastic Stop Nut. They're immediately available from stock.

ESNA Elastic Stop Nuts—with the self-locking, self-sealing and re-usable Red Elastic Collar—are easily adjusted or removed. They provide dependable protection against Vibration, Thread Corrosion, Thread Failure, and Liquid Seepage. ESNA engineers are now ready to study your fastener problems. Address: Elastic Stop Nut Corp. of America, Union, N. J. Sales Engineers and Distributors are conveniently located in many principal cities.

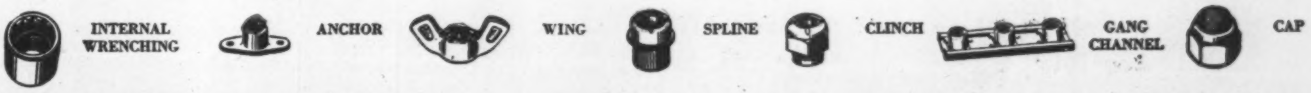
LOOK FOR THE RED COLLAR THE SYMBOL OF SECURITY

It is threadless and dependably elastic. Every bolt—*regardless of commercial tolerances*—impresses (does not cut) its full thread contact in the Red Elastic Collar to fully grip the bolt threads. In addition, this threading action properly seats the metal threads—and eliminates all axial play between the bolt and nut.

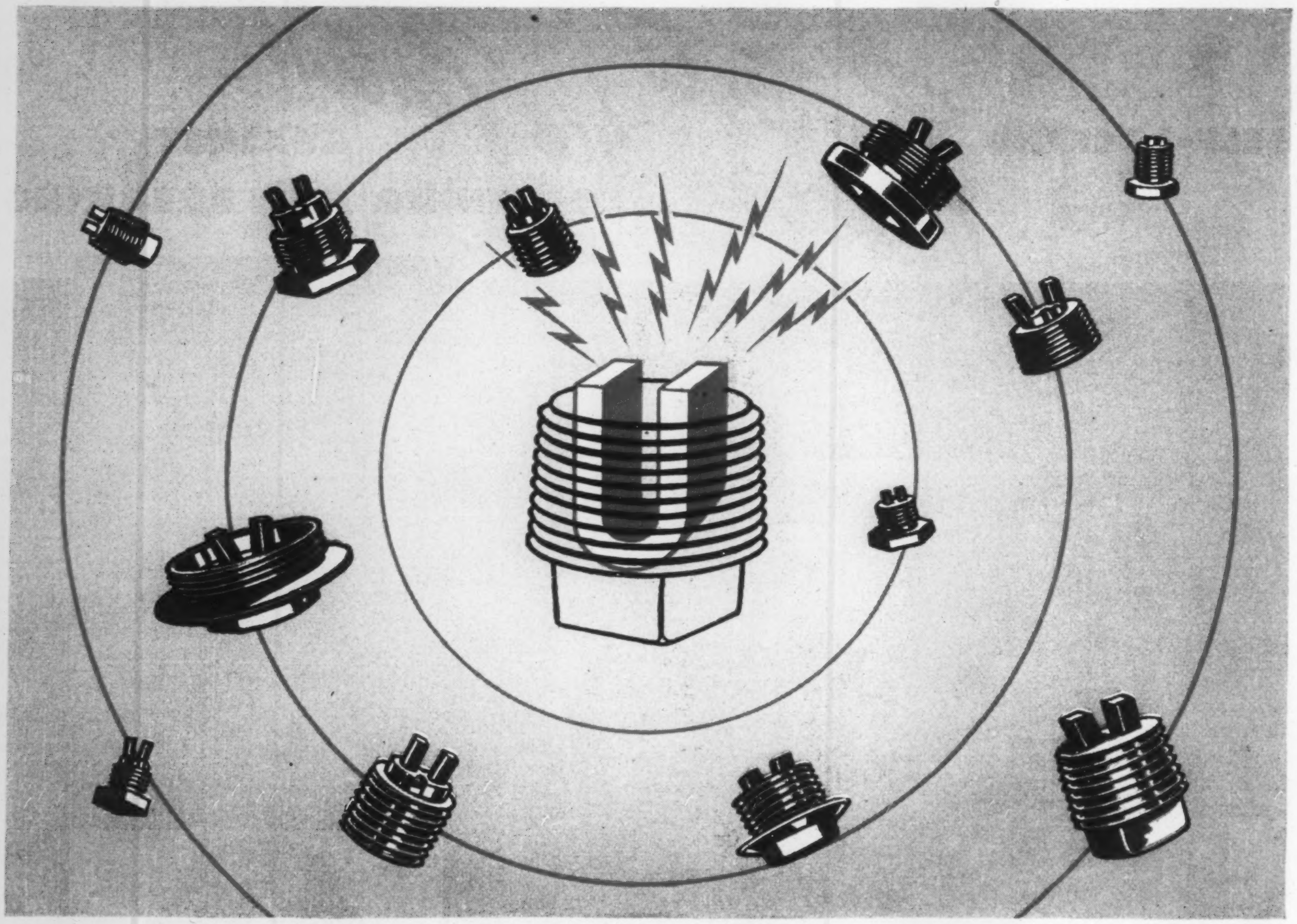
◆ All ESNA Elastic Stop Nuts—*regardless of size or type*—lock in position anywhere on a bolt or stud. Vibration, impact or stress reversal cannot disturb prestressed or positioned settings.

ESNA
TRADE MARK

ELASTIC STOP NUTS



PRODUCTS OF: **ELASTIC STOP NUT CORPORATION OF AMERICA**



Specify LISLE MAGNETIC PLUGS to Protect Your Products

Lisle Magnetic Plugs offer sure, low cost protection for your product against one of the most common causes of bearing and gear failures. Installed in any housing or oil line, the Lisle Plug pulls iron and steel particles or chips out of the lubricant and holds this abrasive matter until the plug is cleaned off.

Lisle Plugs are made in a wide range of styles and sizes to fit every conceivable application. They are now specified as original equipment by over 200 leading manufacturers. —— You are invited to test Lisle Plugs in your product. Sample Lisle Magnetic Plugs in proper sizes will be furnished without charge or obligation.

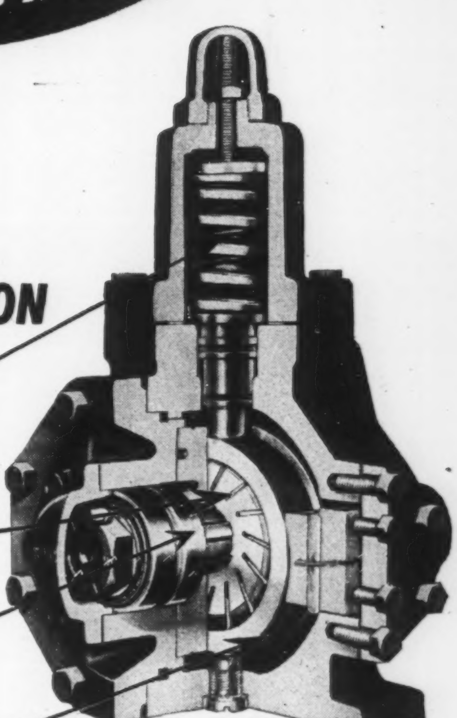
Lisle Magnetic PLUGS

Manufactured by LISLE CORPORATION
Box 1003 Clarinda, Iowa

RACINE

Hydraulics... FOR

SMOOTH POWER MOVEMENTS
IMPROVED MACHINE DESIGN
REDUCED OPERATING COSTS
QUIET, TROUBLE-FREE OPERATION



1 Spring governor provides automatic volume control, supplying only the needed flow of oil at a pre-determined pressure.

2 Tilted vanes cannot seize or gouge the pressure chamber ring. Constant efficiency is maintained.

3 Heavy duty pump shaft is mounted in anti-friction bearings for long life and power saving operation.

4 Pressure chamber ring of special alloy steel is automatically traversed between side plates to vary oil delivery.

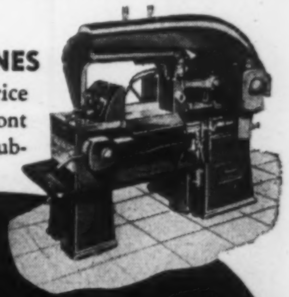
COMMON APPLICATIONS FOR RACINE HYDRAULIC EQUIPMENT

Presses
Machine Tools
Wood Working Machines
Steering Gears
Welding Equipment
Concrete Block Machines
Plastic Presses
Aircraft Equipment
Special Machines

RACINE pumps will simplify your circuits. By-pass and relief valves with the accompanying extra piping are eliminated. Since RACINE pumps by-pass no oil, heating is reduced. Horsepower is saved. Quieter operation results. These features reduce installation cost and operating expense.

Let Racine hydraulic engineers review your applications. This service is available without cost or obligation. Write today, ask for catalog P-10-C. RACINE TOOL AND MACHINE COMPANY, 1773 State Street, Racine, Wisconsin.

RACINE *Hydraulic* METAL CUTTING MACHINES
A complete line in capacities 6" x 6" to 20" x 20" — in all price ranges. Features are simple. One lever control — open front design — progressive feed for cutting any metal from light tubing to tough tool steels. Write for Catalog No. 12.

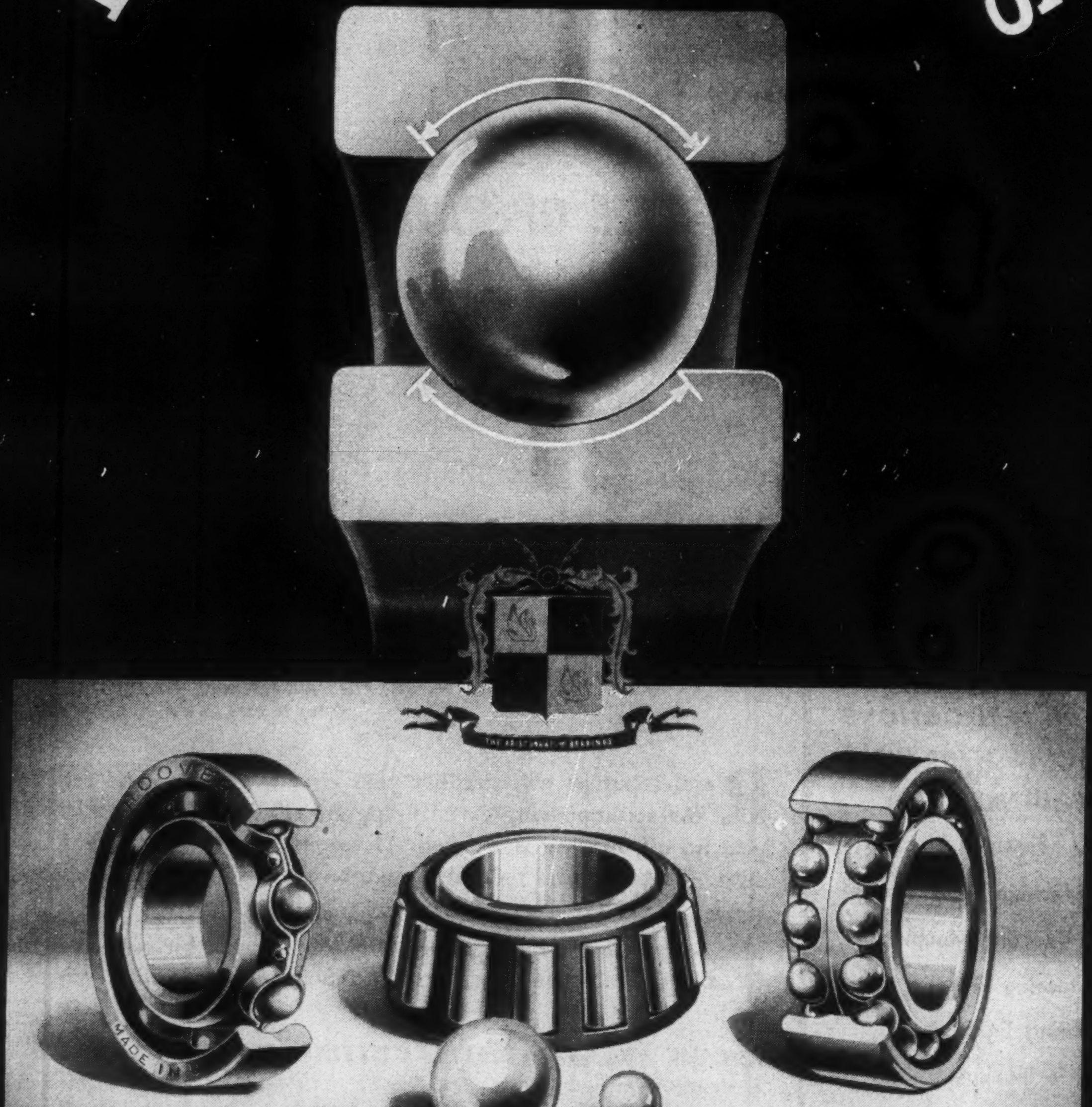


STANDARD FOR QUALITY AND PRECISION · RACINE · RACINE TOOL and MACHINE CO.

RACINE

STANDARD FOR QUALITY AND PRECISION

HONED RACEWAYS
AN EXCLUSIVE HOOVER FEATURE
30%
MORE LOAD—LONGER LIFE



BALLS · BALL BEARINGS · ROLLER BEARINGS

HOOVER

BALL AND BEARING COMPANY, ANN ARBOR, MICHIGAN

FACE MOUNTING
HUB MOUNTING
Robbins & Myers
Robbins & Myers

It's the frame that saves you money...

R & M INTERCHANGEABILITY SOLVES SMALL-MOTOR PROBLEMS

Whether your fractional horsepower needs are few or several, Robbins & Myers motors offer *many distinct advantages* . . . give you *full interchangeability* of *all* motor types in any one frame size . . . *eliminate* expensive redesign when motor requirements change. Compact, well insulated, *standardized* R & M fractionals save you *trouble, time and money.*

ADAPTABILITY IS IN THE MOTOR

The costly problems of special heads and unusual service demands *disappear* in the magic of R & M *application flexibility.* Identical shaft and mounting dimensions make installation easy. Choice of enclosed or open frames—special ventilation—rigid base, resilient base, face, flange, or hub mounting. R & M standardization *lightens your work;* brings *economy* and *practicability* to small-motored equipment.

WIDE RANGE OF TYPES AND SIZES

AC, DC, and Universals—backed by *50 years' success* in building fine motors for equipment manufacturers—are *ready to serve* you. Make R & M *your* standard, too. Write *today* for types, sizes, and engineering specifications.

R & M
UNIVERSAL MOTORS

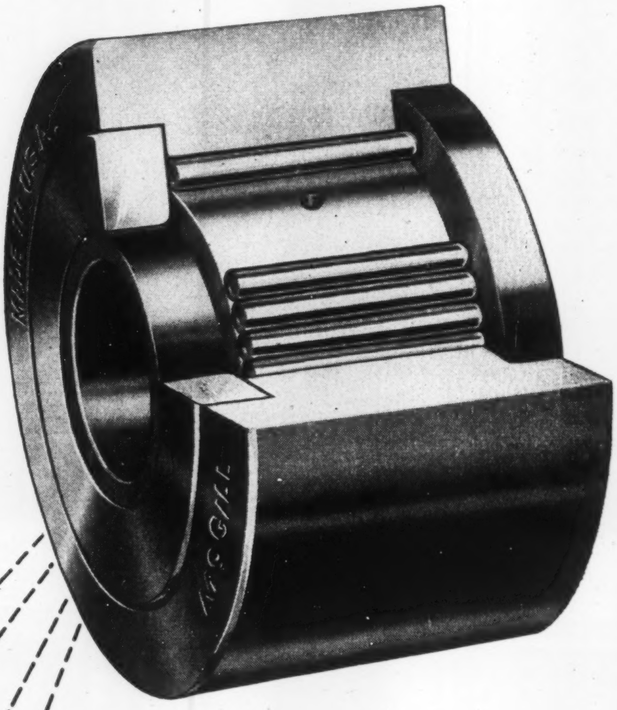
Sleeve or ball bearing
Standard or special rating
Dynamically balanced armatures
Fixed or reversible rotation
Open or totally enclosed
Ample ventilation

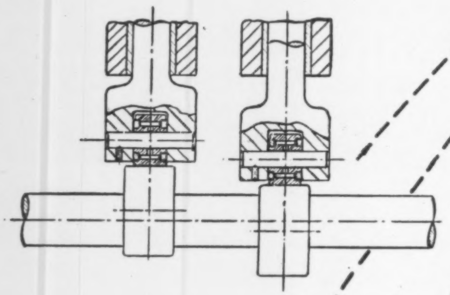
ROBBINS & MYERS · INC. MOTOR DIVISION
Springfield 99, Ohio • Brantford, Ontario

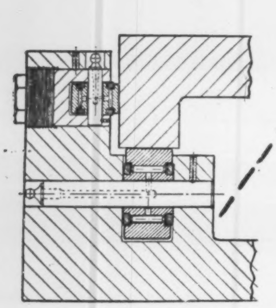
MOTORS • HOISTS • CRANES • FANS • MOYNO PUMPS • FOUNDED 1878

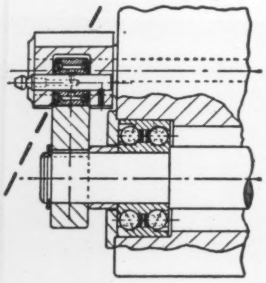
... another McGILL first

THE NEW McGILL MULTIROL® CAM YOKE ROLLER



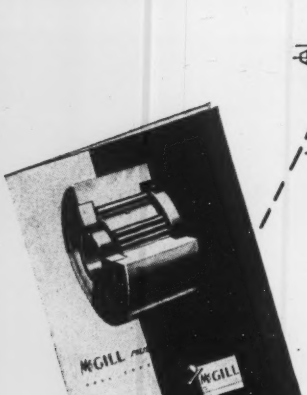






McGill MULTIROL Cam Yoke Roller Bearings represent the latest development in full type roller bearings. The new CYR Series will provide greater adaptability of MULTIROL Cam Followers for all types of automatic machinery. They are specially suited for cam action or controlled motion of machine parts requiring guide or support rollers.

With an inner race replacing the usual stud, a full range of shaft sizes can be accommodated from .250 to 1.25 resulting in almost unlimited methods of mounting. The outer race sections are built extra heavy for shock load resistance and with the same internal construction as the MULTIROL Cam Follower Series. Send your problems to McGill Engineers, McGill Manufacturing Company, Inc., 200 North Lafayette Street, Valparaiso, Indiana.



Write for your free copy of Bulletin CY-47 on the new Multirol CYR Bearings.

McGILL
precision bearings

When and Where you should use . . .

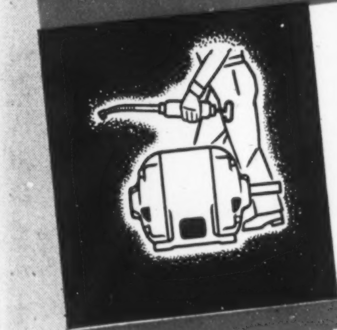
WHERE THERE IS DRIPPING LIQUID

Because Protected-Type motors are dripproof, falling water, oil or other liquids cannot enter the windings. All ventilating openings are shielded.

WHERE THERE ARE FALLING CHIPS

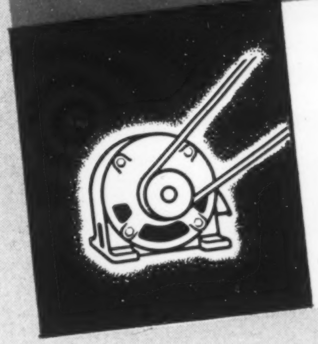
Protected-Type motors are tailor-made for machine tool and other applications where metal chips and other foreign matter might injure the windings of less well-protected motors.

WHEN INSPECTION VISITS ARE FEW AND FAR BETWEEN

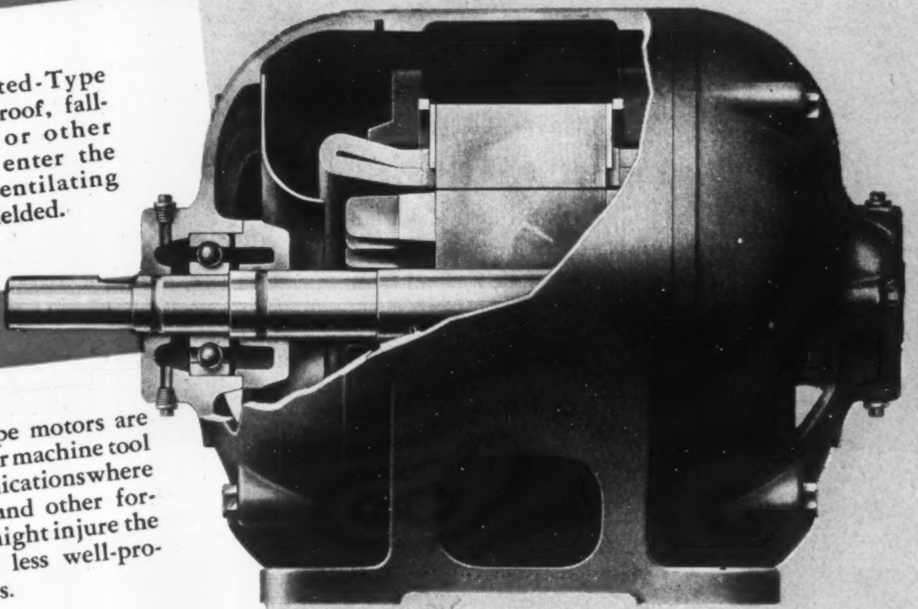


Because rotors are practically indestructible; because stator windings are dirt, oil and moisture resistant to a high degree; because bearing seals are so effective that regreasing is required only once a year or even less frequently—Protected-Type motors require *minimum maintenance.*

FOR ALL GENERAL-PURPOSE APPLICATIONS

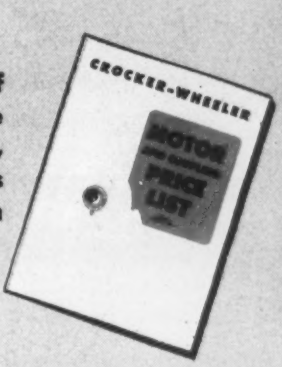


Rated 40C rise, full-load continuous duty, with a 15 per cent overload factor, these motors are suitable for all general-purpose applications for horizontal, vertical or wall mounting. Available in standard ratings from 1 to 1000 hp.



CROCKER-WHEELER *protected-type* MOTORS

Ask for your FREE copy of new, handy, 8-page price list that gives prices, weights and dimensions of standard motors in sizes up to 75 hp.



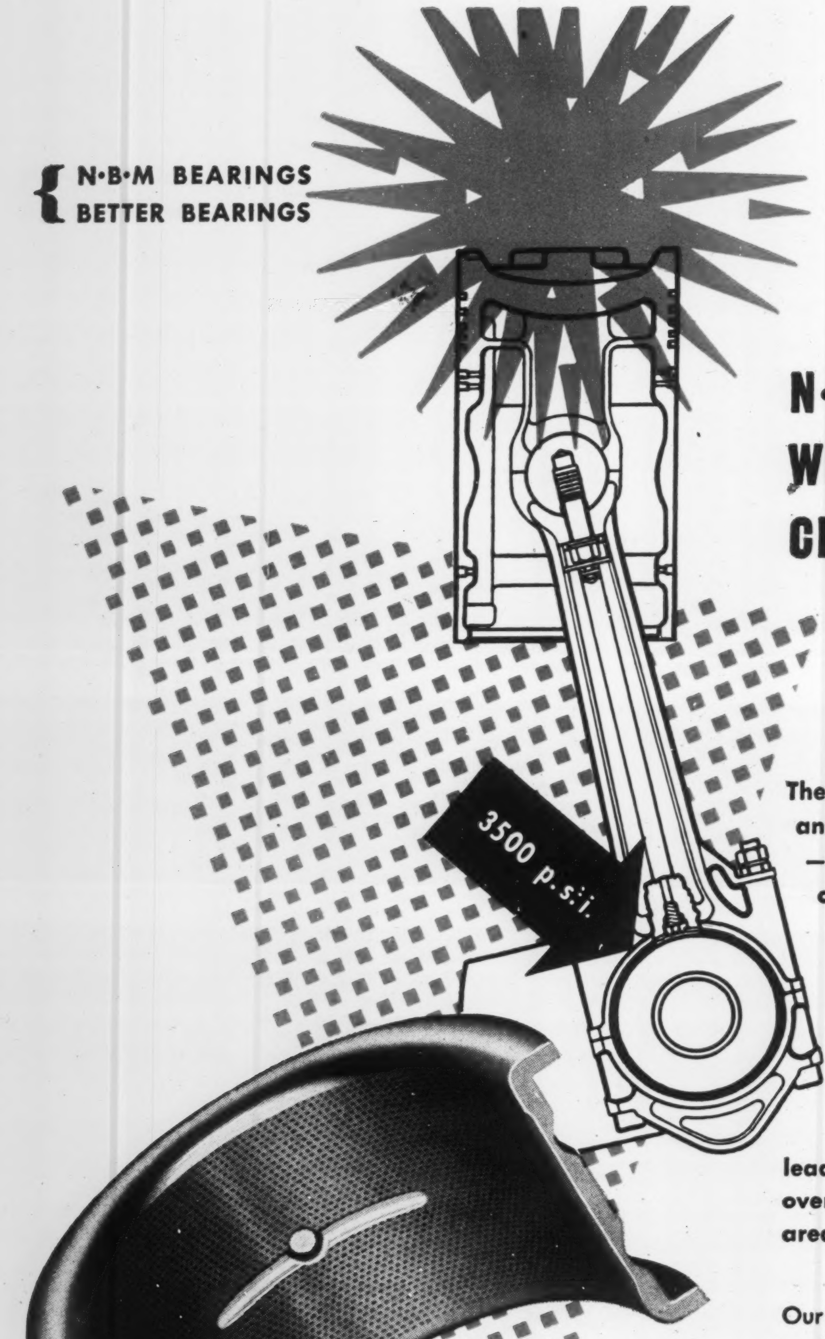
Quality Motors and Generators Since 1888

YOU CAN GET FROM CROCKER-WHEELER:

Polyphase Induction Motors, 1 to 10,000 hp.
Direct Current Motors, 1 to 5,000 hp.
Alternating Current Generators, 500 to 10,000 kva.
Turbo Generators, 1875 to 12,500 kva.
Direct Current Generators, 1 to 3000 kw.
Motor-Generator Sets, 1 to 6000 kw.
Flexible Couplings, for shaft diameters up to 8".

CROCKER WHEELER
ELECTRIC MANUFACTURING COMPANY, AMPERE, N. J.
A Division of Joshua Hendy Corporation
Branch Offices: Boston, Chicago, Cincinnati, Cleveland, Los Angeles, New York
Philadelphia, Pittsburgh — Representatives in Principal Cities

N·B·M BEARINGS
BETTER BEARINGS



N·B·M GRIDDED BEARINGS WITHSTAND CRITICAL FIRING LOADS

EXAMPLE:

These stress-defying bearings set new performance records in heavy-duty diesel engine service —operating in connecting rods under loads of over 3,500 p.s.i. projected area.

REASON:

N-B-M Gridded Bearings combine the *seizure resistance* and *embedability* of Silver Babbitt with the *fatigue strength* and *conformability* of centrifugally cast lead bronze. They are "self-healing": in case of overstress, melted babbitt flows over the critical area to prevent damage to shaft or bearing.

Our exclusive new manufacturing process makes them available at "mass-production" savings so you can use them freely. May we send complete engineering data?

NBM

AMERICAN
Brake Shoe
COMPANY

NATIONAL BEARING DIVISION
ST. LOUIS · NEW YORK

PLANTS IN: ST. LOUIS, MO. • PITTSBURGH, PA. • MEADVILLE, PA. • JERSEY CITY, N. J. • NILES, OHIO • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

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HELPFUL LITERATURE

FOR DESIGN EXECUTIVES

62. Aluminum Lighting Fixtures

Reynolds Metals Co.—12-page illustrated catalog No. Y-723 presents information on the characteristics of aluminum such as high reflectivity, immunity to rust, high ratio of strength to weight, workability and high thermal and electrical conductivity when applied to lighting fixtures. Many types of lighting systems are shown.

63. Copper Alloy Specifications

American Brass Co.—28-page "Copper and Copper Alloy Specifications Index" devotes one section to parts lists of generally used alloys together with applicable specifications, and another section lists specifications in numerical order with brief description of material as to grade, type, temper, anneal, etc.

64. Electrical Regulation

Westinghouse Electric Corp.—36-page illustrated booklet No. B-3649 presents Rototrol, tells what it does and how it works. Used for regulating voltage, speed, current, power, torque, power factor and position, and providing stability control and current limiting, Rototrol is applicable in wide range of industries. Theory, design and operating principles are covered.

65. Gasoline Engines

D. W. Onan & Sons Inc.—Two illustrated data sheets cover general specifications and special accessories of model CK gasoline engines. Data sheet No. 706C describes model CK-MS 10-horsepower unit which is four-cycle, air cooled engine weighing only 97 pounds, and data sheet No. A186 describes models BH-S 5½-horsepower unit and COM-1B 3½-horsepower unit. Manual and electric starting information is included.

66. Electrical Connectors

Scintilla Magneto Div., Bendix Aviation Corp.—4-page illustrated folder "Bendix-Scintilla Bus-K-Nect" reveals information on electrical connector designed to speed battery changes and reduce fire hazard. Unit consists of junction box which accommodates three terminals in compact arrangement.

67. Air Control Valve

Knox Industries, Inc. — 4-page illustrated folder "Air-Miser" describes four-way by-pass air valve intended for use with double acting air cylinders. Valve is of disk type, self-sealing, easy to operate and fast acting. By-pass port in bronze disk allows half of compressed air used in power stroke of double acting air cylinder to be used to return piston to starting position.

68. Mercury Lamps

General Electric Co.—8-page illustrated folder No. Y-729 describes mercury lamps for industrial lighting in medium and high-bay interiors. Advantages include low operating and maintenance costs, fewer lamps required per installation and light values that blend well with daylight and other light sources. Typical installations are shown and physical and electrical specifications of 400 and 3000-watt lamps are given.

69. Steel Plate

Jos. T. Ryerson & Son, Inc.—8-page illustrated bulletin describes special type of high-manganese high-sulphur analysis steel plate developed especially for applications involving machining such as production of rubber molds, machine parts, die bases, jigs, fixtures, etc. Analyses, physical properties and machining advantages are described and data on welding and properties developed by case carburizing are covered.

70. Adjustable V-Belts

Manheim Mfg. & Belting Co.—Illustrated catalog on Veelos V-belts describes features and construction details of adjustable V-belts and illustrates how to couple and uncouple, measure and install them. Engineering data and 13 pages of application photos cover installations in wide variety of industries.

71. Metal Hose & Couplings

Flexpansion Corp.—4-page illustrated folder briefly describes flexible metal hose assemblies and series of couplings. Numerous types are shown in cross-section views and features of each are outlined.

72. Leather Belting

J. E. Rhoads & Sons—23-page illustrated data book presents information about Tannate leather belting for Rockwood short center, pivoted motor base drives. Engineering data for design and installation are presented and worksheet of typical layout is given.

73. Industrial Controls

Photoswitch Inc.—4-page illustrated bulletin No. 504 describes line of photoelectric controls, electronic timers and pilot relays, level controls, smoke controls and registration controls. Operation and applications of equipment are outlined.

74. Ball Bearings

Marlin-Rockwell Corp. — 6-page illustrated vest-pocket size folder No. 1526 charts bore, outside diameter, width, radius and ball size of type MRC 200-SZZ light series and type MRC 300-SZZ medium series synthetic-seal ball bearings. Seal retains lubricant and excludes dirt, grit and moisture.

75. Over-Running Clutch

Gear Grinding Machine Co.—4-page illustrated bulletin describes Formsprag full complement over-running clutch which permits maximum torque capacity for size and weight of unit. Applications include use on multiple speed drives in which unit cuts off low speed automatically when high speed cuts in. On dual drives or where stand-in power unit is employed, unit permits use of either power drive or both together.

76. Castings & Patterns

Wellman Bronze & Aluminum Co.—16-page illustrated revised catalog No. 47 presents features of nonferrous castings and patterns. Technical tables cover relative weights of structural metals; physical and mechanical properties of cast metal; chemical compositions and mechanical properties of magnesium, aluminum and copper-base alloys and Ampco metal, and other data.

77. Valves

Hanna Engineering Works—8-page illustrated bulletin No. 235 gives specifications and operating data on all Hanna valves. Line consists of foot and hand-operated valves for air and hydraulic lines, and speed control valves for use with air and hydraulic cylinders.

FOR MORE INFORMATION

on developments in "New Parts" and "Engineering Department" sections—or if "Helpful Literature" is desired—circle corresponding numbers on either card below.

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78. Industrial Lighting

Vimco Mfg. Co.—4-page illustrated folder No. 74 describes six standard models and presents price list of line of general machine lights for localized incandescent high-intensity lighting applications.

79. Forgings

Jos. Dyson & Sons, Inc.—6-page illustrated bulletin "There Is No Substitute For Quality" deals with line of forged nuts 3 inches and larger, flat die forgings from 10 to 14,000 pounds and hydraulic pressed forgings made to close tolerances.

80. Synthetic Rubber

Acadia Synthetic Products Div., Western Felt Works—32-page illustrated catalog "Synthetic Rubber Data" presents results of laboratory evaluation of synthetic rubber polymer compounds after they have been exposed to various oils, fuels and solvents. Molded items, extruded shapes, sheets, roll goods and die-cut parts are all illustrated and discussed.

81. Clutches

Mercury Clutch Corp.—20-page illustrated catalog "Mercury Clutches" is compilation of four bulletins which deal with starting and accelerating high inertia loads by means of small mercury clutches. Mercury in inner ring of gland has high inertia and low viscosity to delay acceleration so that friction members are not engaged for about 1½ seconds.

82. Gears

Illinois Gear & Machine Co.—64-page illustrated catalog No. 39 presents information and lists prices, types and sizes of gears for various industrial applications. Items covered include Bakelite spur pinions, bevel gears, bevel and miter gears, Fabroil spur pinions, helical gears, spiral gears, sprockets, spur gears, etc.

83. Stainless Steel

Washington Steel Corp.—4-page illustrated folder "Designs of the Future" describes four types of MicroRold stainless steel sheet and strip material. Analysis and average physical properties of each type are given and information relative to temper and finish are included.

84. Resistance Seam Welding

Taylor-Winfield Corp. — 16-page illustrated bulletin No. SP-7 deals with resistance seam welding of low carbon and stainless steels. Methods utilizing both continuous and interrupted current are covered. Preparation of parts, electrode drives and time element involved are discussed.

85. Instrument Knobs & Dials

Kurz-Kasch, Inc.—12-page illustrated catalog No. 103A deals with stocked line of plastic radio and instrument knobs and control balls and manufacturing facilities available to produce molded plastic controls to any specification. Various styled knobs are shown.

86. Refrigeration Units

Refrigeration Div., Bowser, Inc.—50-page illustrated loose leaf type catalog "Industrial Temperature, Altitude and Humidity Units" is compilation of bulletins Nos. 1 through 10 dealing with high and low temperature processing and testing equipment. Engineering service available is covered also.

87. Magnetic Plugs

Lisle Corp.—21-page illustrated loose-leaf type brochure entitled "Lisle Magnetic Plugs" explains protection of bearings, gears and other moving parts against excessive wear offered by these plugs. What they are, how they function and numerous typical applications are described.

88. Gasoline Engines

Uebelhoer Bros., Inc. — 4-page illustrated folder "Ultimotor" outlines advantages of use and mechanical specifications of model U-100, 2.4-horsepower, four-cycle Ultimotor gasoline engines designed for powering saws, pumps, hoists, conveyors, compressors, tractors, generating plants, etc.

89. Marking Tools

M. E. Cunningham Co.—8-page illustrated bulletin No. J-547 features line of safety marking and stamping tools for all industrial purposes . Tools are made of Mecco alloy steel which eliminates mushrooming and spalling and minimizes accidents caused by flying chips.

90. Protective Coatings

American Chemical Paint Co.—8-page illustrated technical service data sheet No. P-100-21 is reference list of rustproofing chemicals, protective coatings, metal cleaning chemicals and inhibitors. Metal and process index provides quick reference to recommended chemicals for all types of processing.

91. Die Castings

Doehler-Jarvis Corp. — 32-page illustrated brochure entitled "Successful Die Castings" describes skill, experience and manufacturing facilities for producing die castings to order in five strategically located plants. Facilities, names of personnel and other information are given.

92. Relays

Phillips Control Corp.—12-page illustrated catalog No. 7 presents data on nine types of Phil-trol relays as well as on accessories and contact assemblies. Relays are particularly suited for electronic and industrial control, signal and traffic control, radio, communications, aircraft and similar uses.

93. Steel

Allegheny Ludlum Steel Corp.—62-page indexed stock list of tool and high speed steels indicates types, shapes and sizes available and tells at which of eighteen warehouses material is stocked. Listings are shown in quickly located chart form for convenience of users.

94. Metal Tubing & Couplings

International Metal Hose Co.—4-page illustrated folder "Flexible Metal Tubing . . . and Couplings" gives inside and outside diameters, weight per 100 feet and bending radius of types B, BB and C flexible metal tubing. It is available in galvanized steel, brass, stainless steel and aluminum.

95. Precision Groundparts

Jerpbak Bayless Co.—4-page illustrated folder "Precision Ground" presents information of line of worms, lead screws, thread ground products and wheel crushing rolls. Manufacturing facilities available for production of miscellaneous thread ground parts etc. are covered.

96. Hydraulic Pumps

Denison Engineering Co.—4-page illustrated folder No. 126 outlines features and operating data on three available sizes of 3500 series HydrOILic pumps which combine high pressure with high volume delivery. Typical performance chart of pumps is presented and engineering information and adaptability are discussed.

97. Oil Heaters

Ross Heater & Mfg. Co.—16-page illustrated bulletin No. 3624-A presents information on line of type O straight tube heaters or preheaters and type TS tank suction heaters designed for heating fuel oils and similar viscous liquids, and heavy fuel oils and tar respectively.

98. Tracing Vellum

Craftint Mfg. Co.—6-page illustrated vestpocket size folder "Quick as a Wink" presents information on two types of Doubletone tracing vellum. Upon application of special developer, lines or cross hatching processed in paper are brought out. One type of vellum can be used for preparation of tracings to be reproduced by direct contact printing and the other for tracings to be reproduced by photographic methods.

99. Automatic Lubrication System

Bijur Lubricating Corp.—12-page illustrated bulletin No. 4A describes automatic metered lubrication distribution system in which pump feeds definite volume of oil into lubrication system where meter units apportion oil-feed to individual bearings. Planning and applying system to typical machines are covered, and system fittings and installation details are described.

100. Blueprinting Machine

Paragon-Revolute Corp.—6-page illustrated folder No. 447 presents operating data and specifications of model M4 automatic blueprinting machine which is capable of high speed production of blueprints, whiteprints, vandyke prints and blueline prints. Feeding, chemical application, washing, temperature control and paper tension features are covered.

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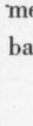

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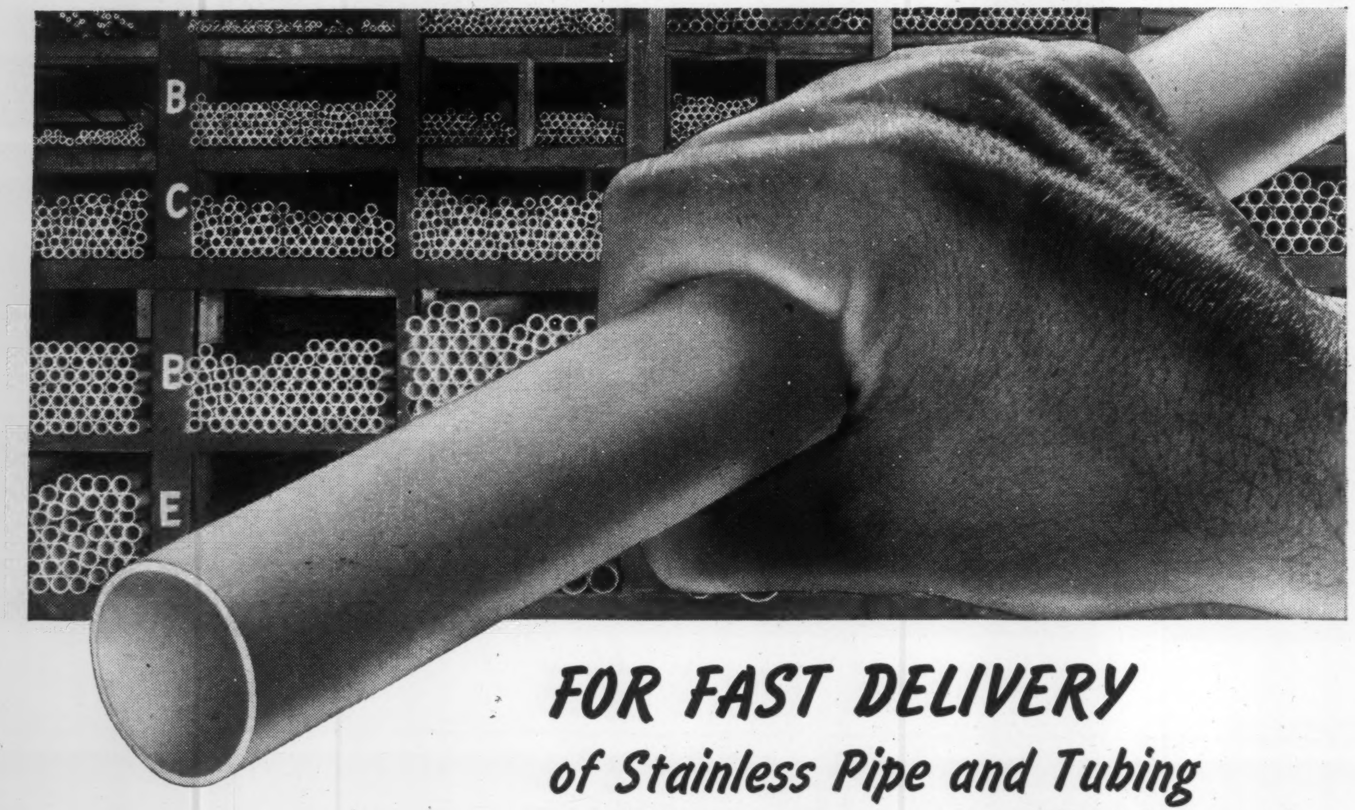

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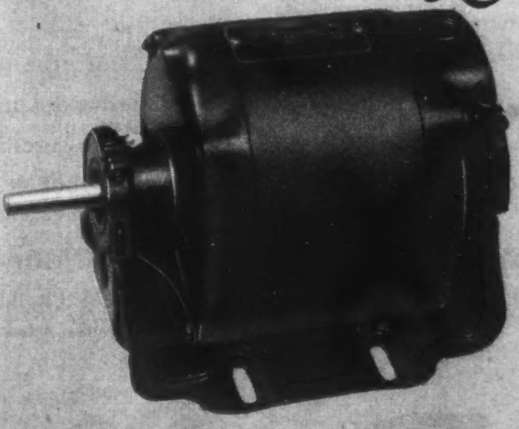

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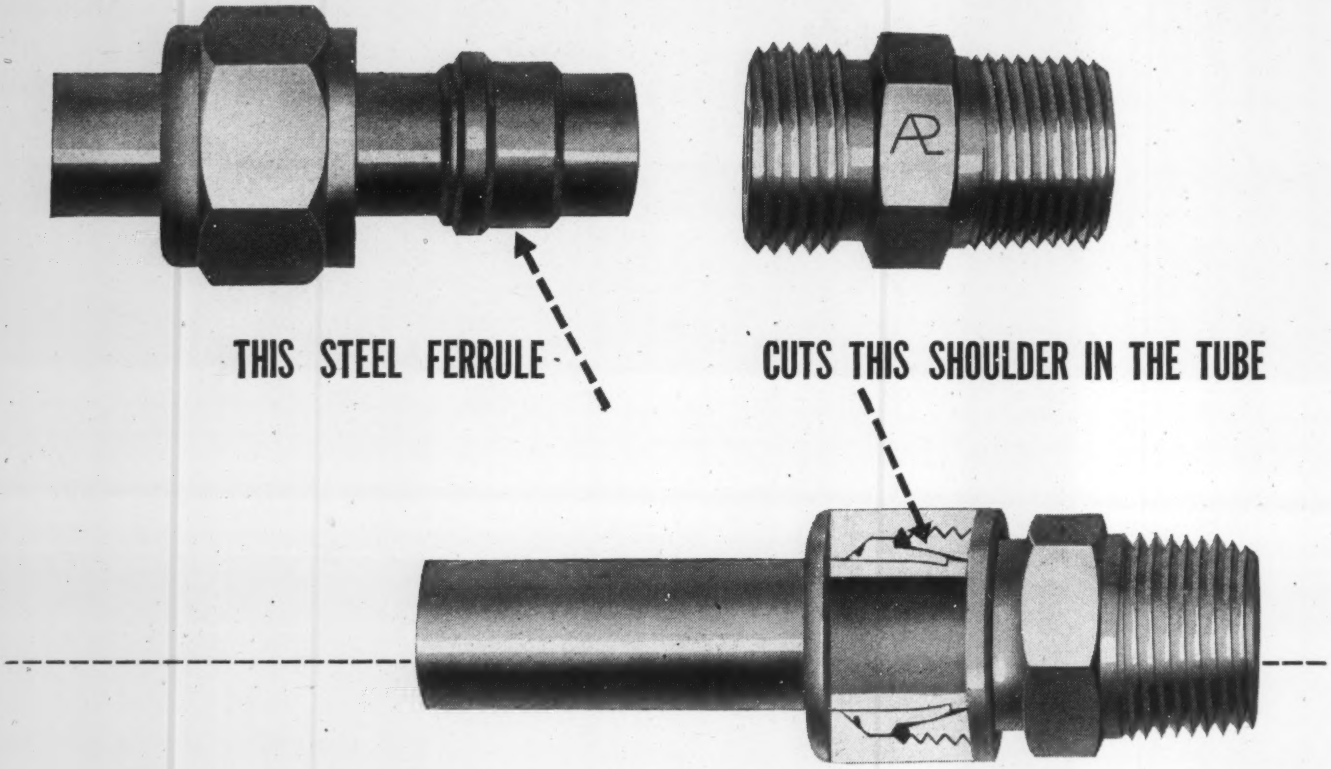

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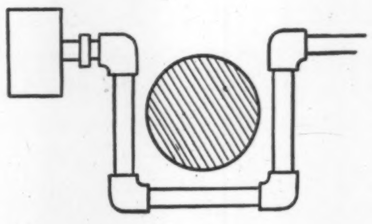
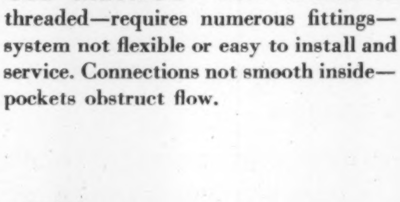


OLD METHOD—Each connection threaded—requires numerous fittings—system not flexible or easy to install and service. Connections not smooth inside—pockets obstruct flow.



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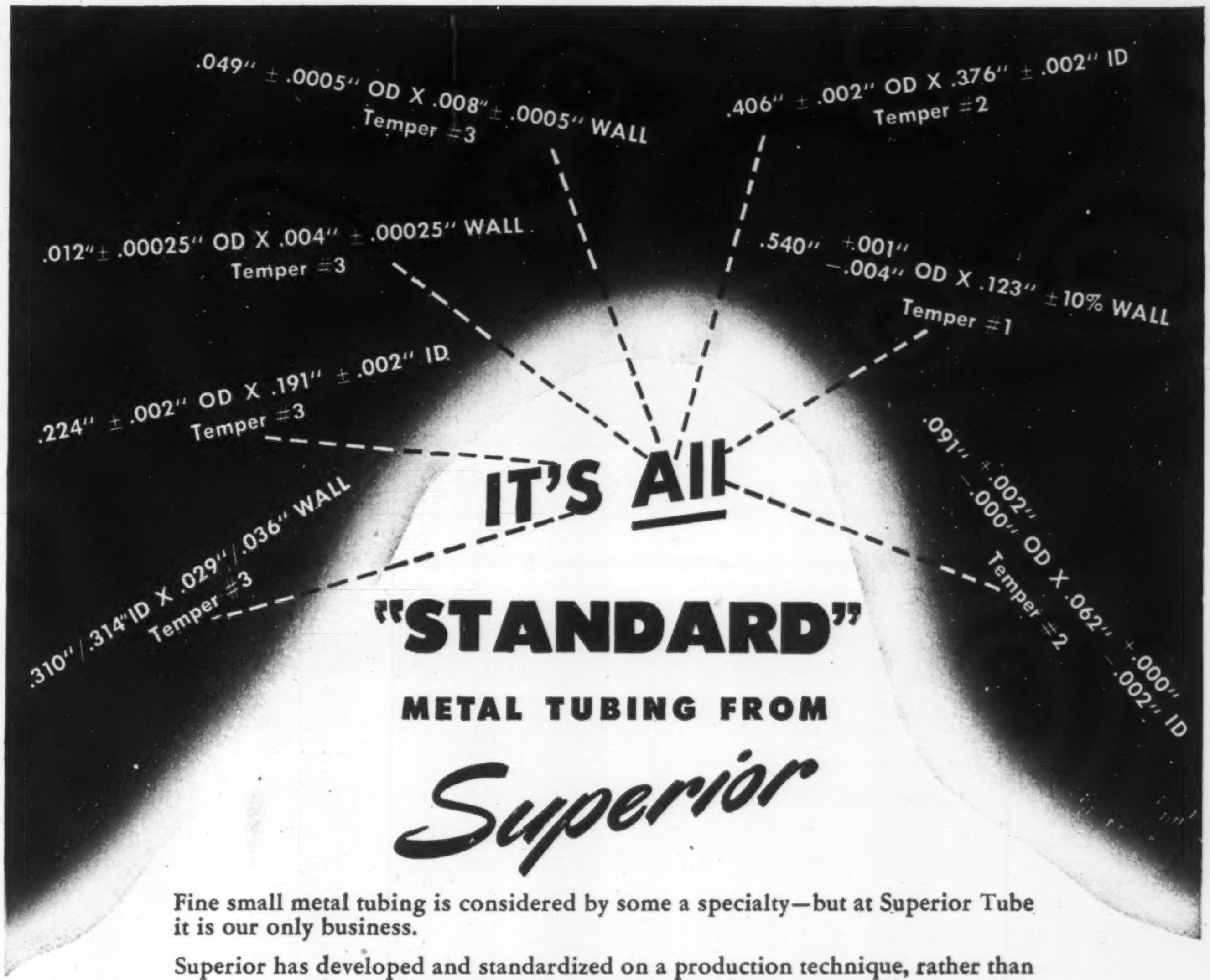
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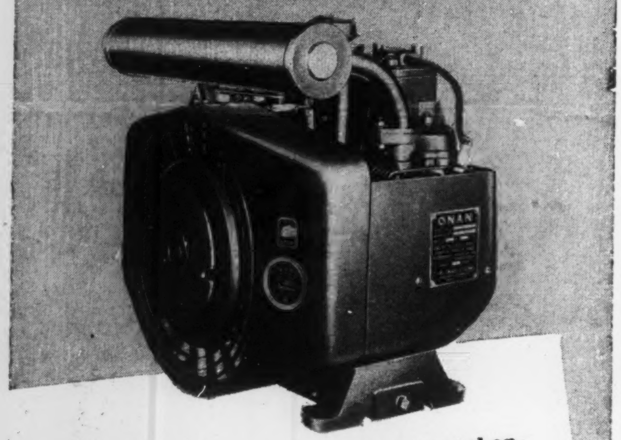

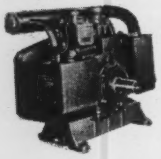

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Electric Starting

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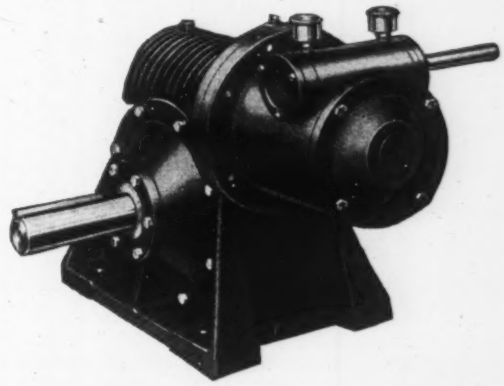

JANETTE Offers the Manufacturer of slow speed machines a large variety of sizes and types of EITHER MOTORIZED or MOTORLESS speed reducers. They are compact, pleasing in appearence, ruggedly constructed, with ample sized gears, shafts, bearings and bases to insure many years of trouble free service.

SPEED REDUCERS provide a practical, simple method for obtaining slow speeds from efficient, high speed motors, without using chains, sprockets, belts, pulleys or exposed gearing.

JANETTE build their own motors which are especially designed for driving speed reducers. Because of the large variety of reducers available, there is a size and type for almost any commercial application.

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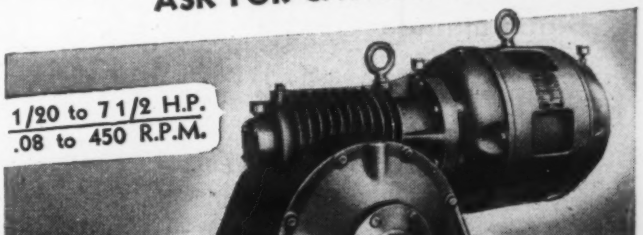

Janette Manufacturing Company
556 W. Monroe St. Chicago 6, Ill.

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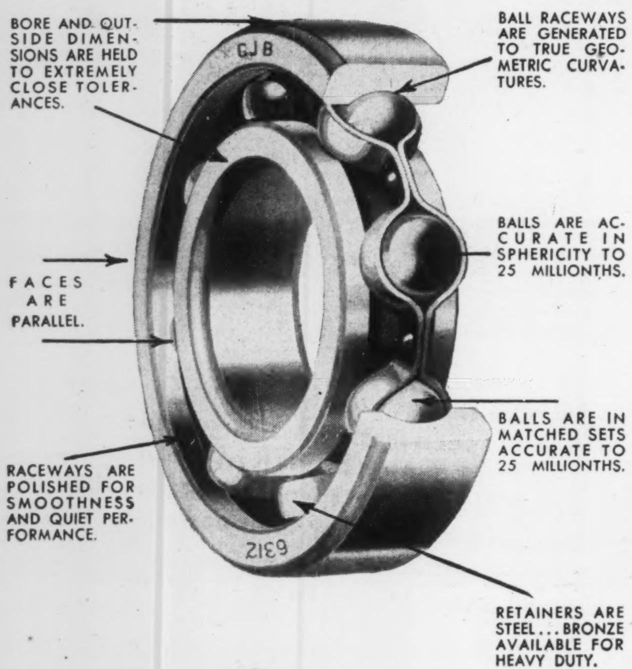

BORE AND OUTSIDE DIMENSIONS ARE HELD TO EXTREMELY CLOSE TOLERANCES.
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CJB Ahlberg Ball Bearings are precision assemblies of these quality components, engineered and manufactured for top performance. **Ahlberg Bearing Company, 3017 West 47th Street, Chicago 32, Illinois.**

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HILLIARD CLUTCHES AND COUPLINGS

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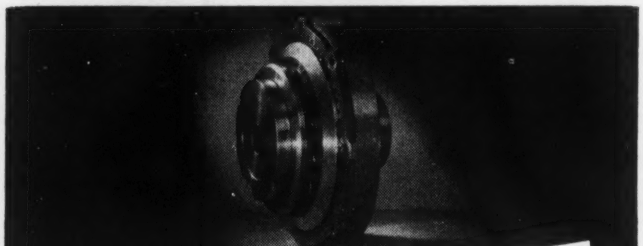

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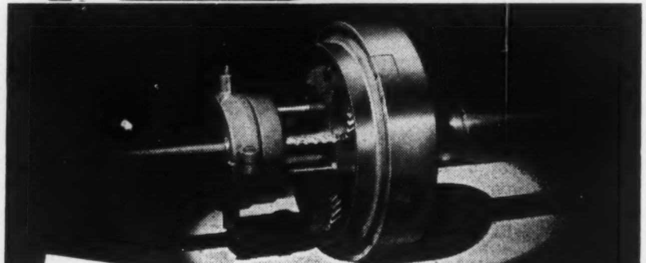
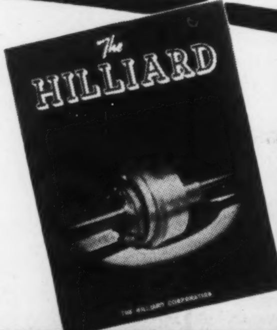
A reliable series of spring-loaded slip clutches and couplings made in a variety of types. Outstanding for—reeling and winding operations—tension drag brakes—limiting torque—preventing overloads and shocks—starting heavy loads—and many other uses.



HILLIARD FRICTION CLUTCH

Hilliard Friction Clutches and Couplings are especially suitable for drives requiring smooth clutching and infrequent clutch adjustment. Their rack and gear mechanism permits very slow engagement of friction surfaces, resulting in extremely smooth load acceleration, always under control.



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Job time cut from 6 hours to ONE

Read What Mr. Burt Sheehan, Plant Engineer of the Preservative Paint Co., Seattle, Washington, says about their Roper Installation.

● "Our product, Plastic Leak-Tite, is a heavy roof putty for stopping leaks on asphalt roofs and around flashings ● Containers were previously filled by hand with a putty knife and scoop. ● With the Roper Pump installation we now fill in one hour the same number of containers that were formerly filled in six hours. ● In addition to the saving of time, the operation is very much cleaner and neater."

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Another example of Roper engineering solving one of those so-called "impossible" jobs . . . transferring a heavy viscous roofing compound at a maximum speed of 16 g.p.m.

The Roper Pump is mounted with a 3 h.p. motor, backgearing and 4-speed transmission on an Air Corps bomb truck so as to facilitate moving the equipment from one batch mixer to another. Let Roper engineering help solve your pumping problems!

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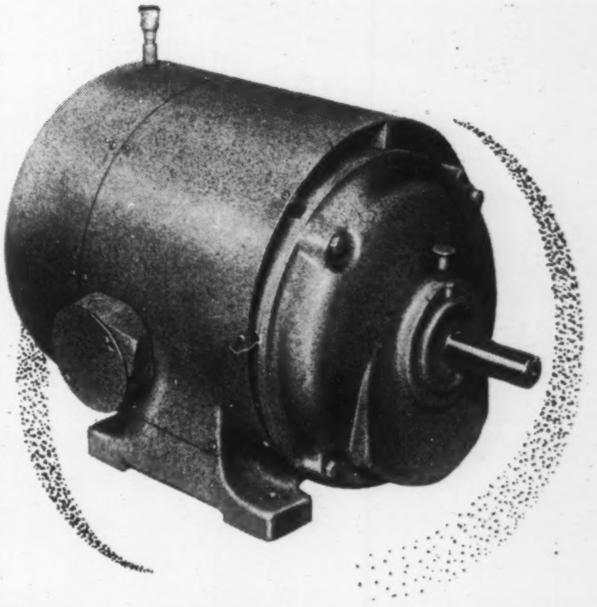

This Welco motor wears Goggles

Heavy dust and abrasive grit call for goggles and masks to protect the humans who work on them. The vital parts of an electric motor require protection too. This special Welco Torque Motor is enclosed and fan cooled. It can be used in heavy concentrations of dust, such as are often present in foundries, textile and chemical industries.

This is just one example of Welco special motor engineering. Wherever the power job or the conditions are tougher than ordinary, call on Welco. We go to work where standard motors leave off.

B. A. WESCHE ELECTRIC CO.
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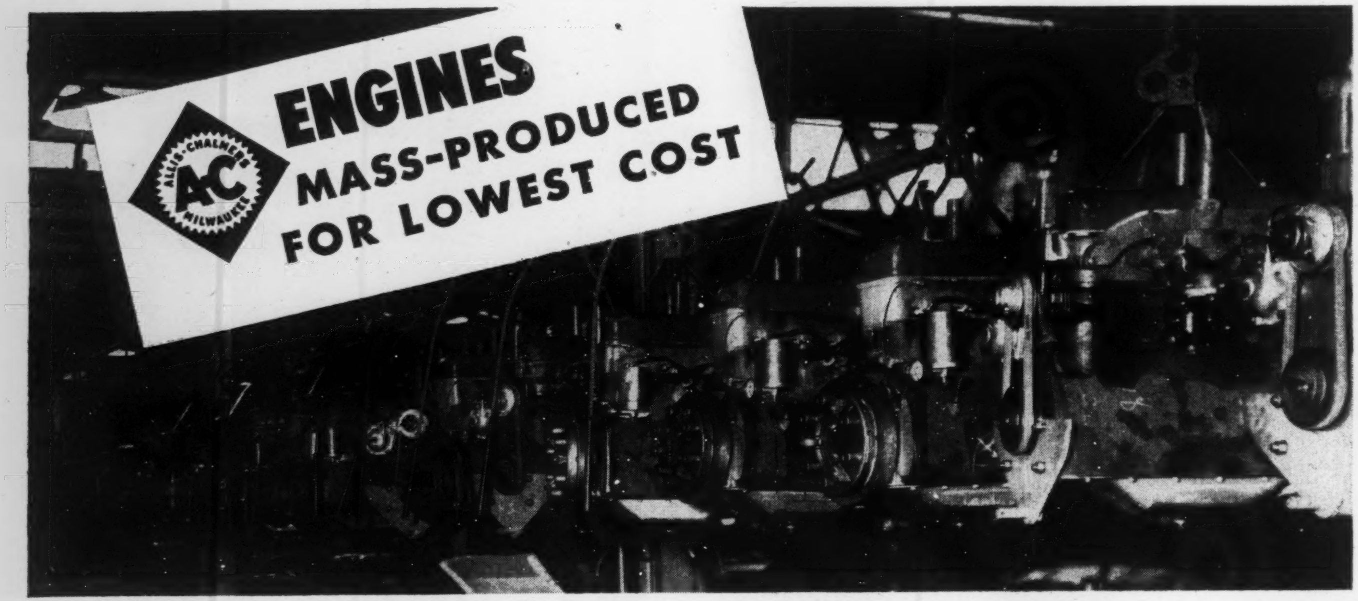

Here is the reason you get Allis-Chalmers Power Units at a lower cost . . . they are *mass-produced* — along with engines by the thousands for tough tractor service. The user enjoys the savings . . . as well as inter-changeability of parts, and the other advantages of mass production. Low costs, plus "tractor-service" stamina, help build product acceptance and good will. Investigate rugged, high-torque A-C Engines for your products. Accessories to fit application. Choice of fuel. Our power engineers will gladly help select the correct unit for your needs.

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Five Sizes

Model B-15	4 Cyl.,	24 Max. B.HP. at 1500 R.P.M.
Model W-25	4 Cyl.,	31.5 Max. B.HP. at 1300 R.P.M.
Model U-40	4 Cyl.,	45 Max. B.HP. at 1200 R.P.M.
Model E-60	4 Cyl.,	74 Max. B.HP. at 1050 R.P.M.
Model L-90	6 Cyl.,	110 Max. B.HP. at 1050 R.P.M.

ALLIS-CHALMERS
TRACTOR DIVISION • MILWAUKEE 1 U.S.A.

VALVAIR Solenoid Valves

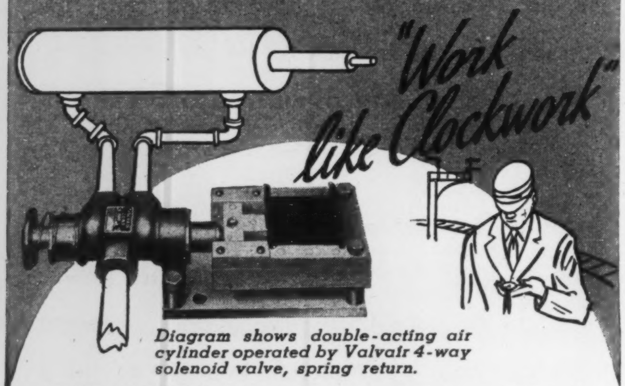

Diagram shows double-acting air cylinder operated by Valvair 4-way solenoid valve, spring return.

DEPENDABILITY — That's outstanding in Valvair performance. Solenoids are Stellite-welded to resist wear; do not mushroom. Standard Valvairs have operated over 2,000,000 times at 100 lbs. with never a leak. *Exclusive features.* Patented basic design eliminates metal seats; non-corrosive (cast bronze body, stainless steel parts); full pipe area used with minimum drop. 2-way, 3-way, 4-way types. Get full details and prices.

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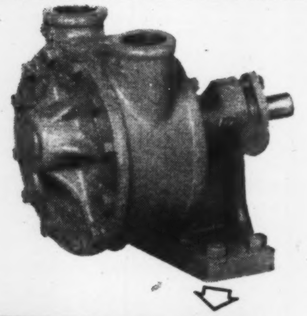

It Pays to Specify TUTHILL Model C for General Purpose Pumps

Low in first cost and engineered for long service with negligible maintenance, Tuthill Model C pumps are outstanding in general service on non-corrosive liquids. Compact and built for rugged service, these internal-gear rotary pumps operate efficiently in either rotation. Capacities from 1 to 200 g.p.m. at pressures up to 100 p.s.i. Direct drive, belt drive, V-belt units and stripped models available. Write for Model C bulletin.

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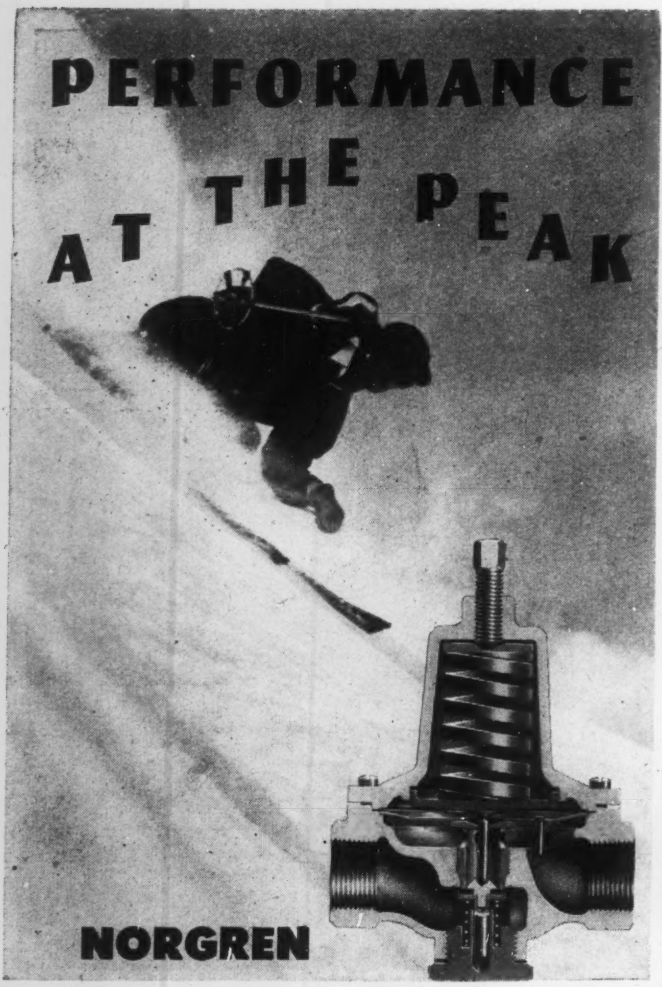

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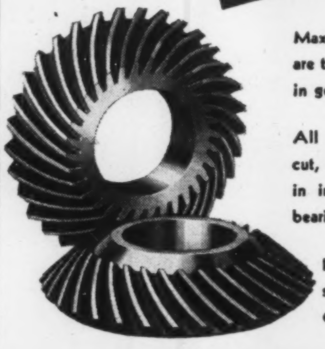

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All Cincinnati Spiral Bevel Gears are cut, tested, matched, lapped and marked in individual sets . . . to insure correct bearing location on teeth.

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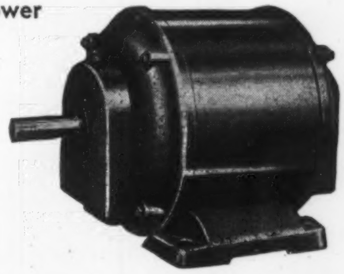

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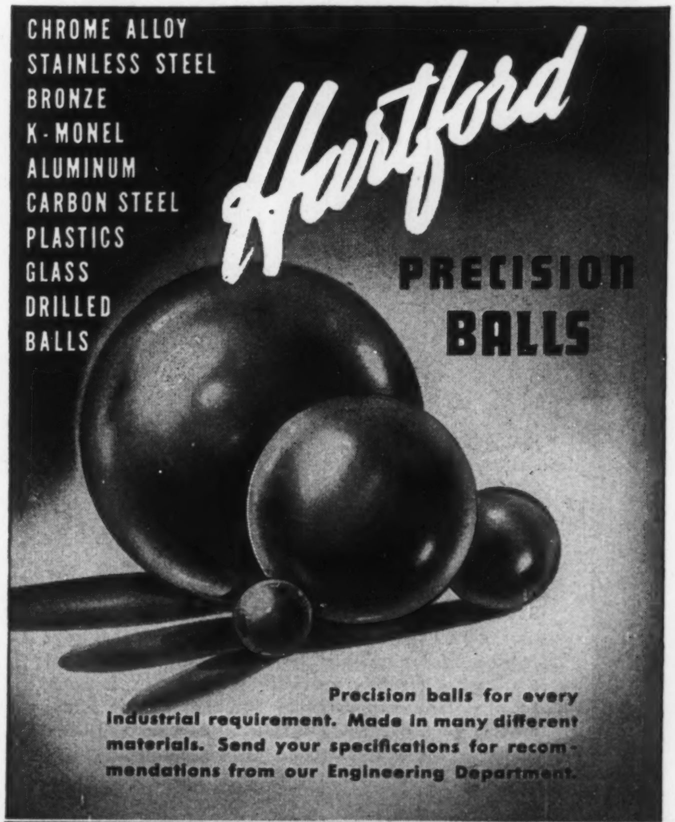

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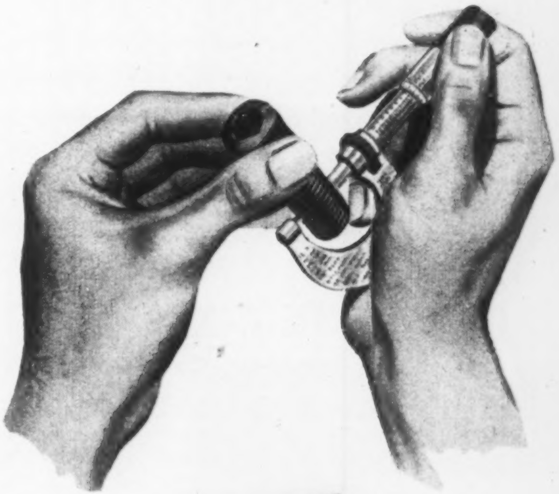

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Please send Free Catalog listing styles, sizes, prices and specifications of "Blue Devil" products.

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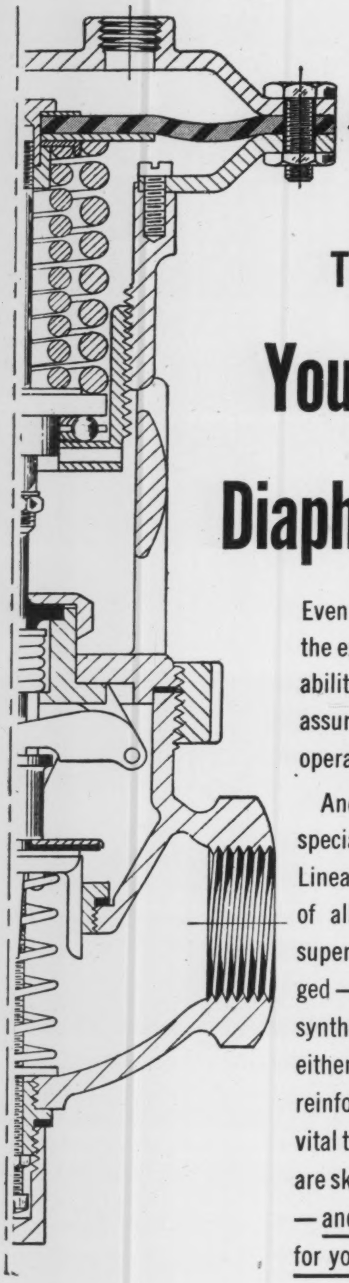

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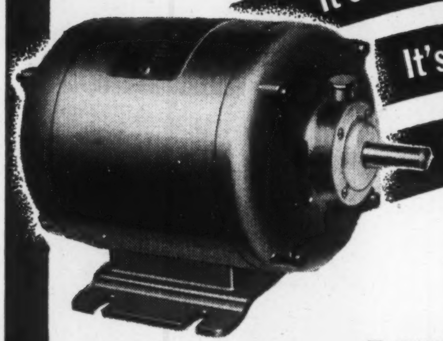

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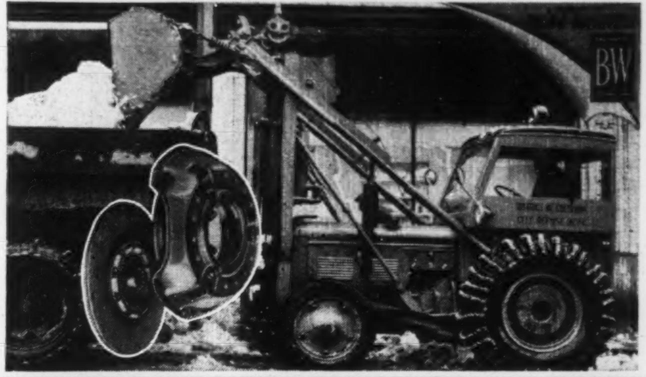

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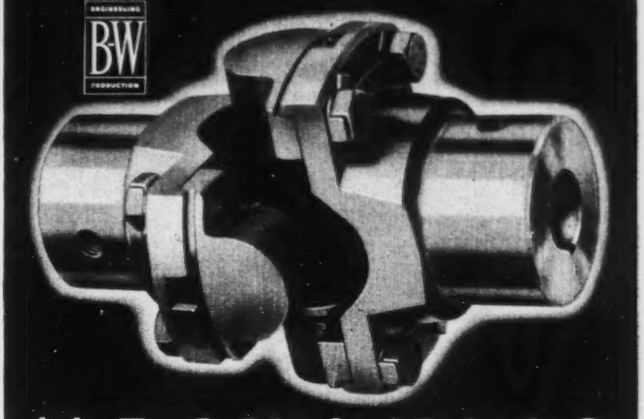

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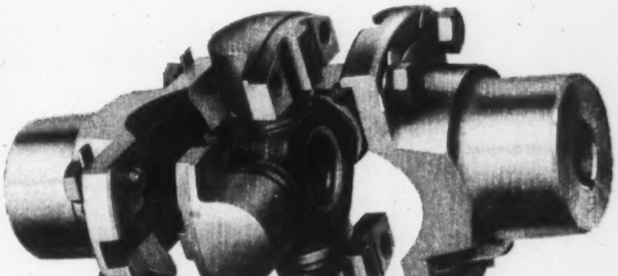

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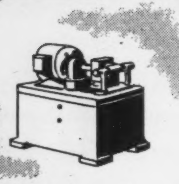
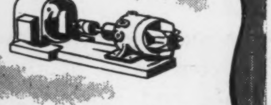


It's firm—neither loses its shape nor frays . . . can be cut to tolerances measured by thousandths of an inch.



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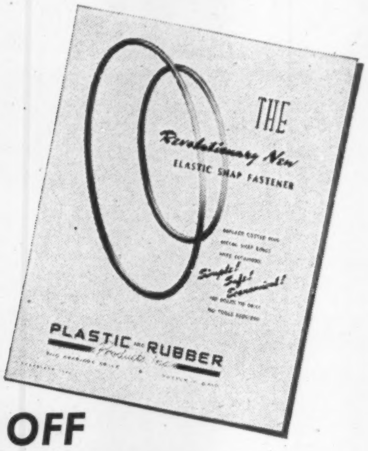

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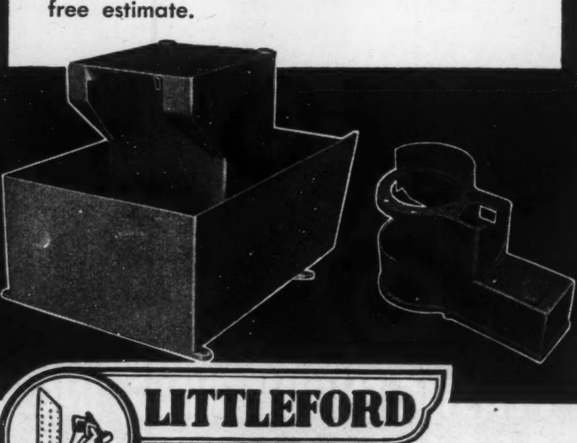

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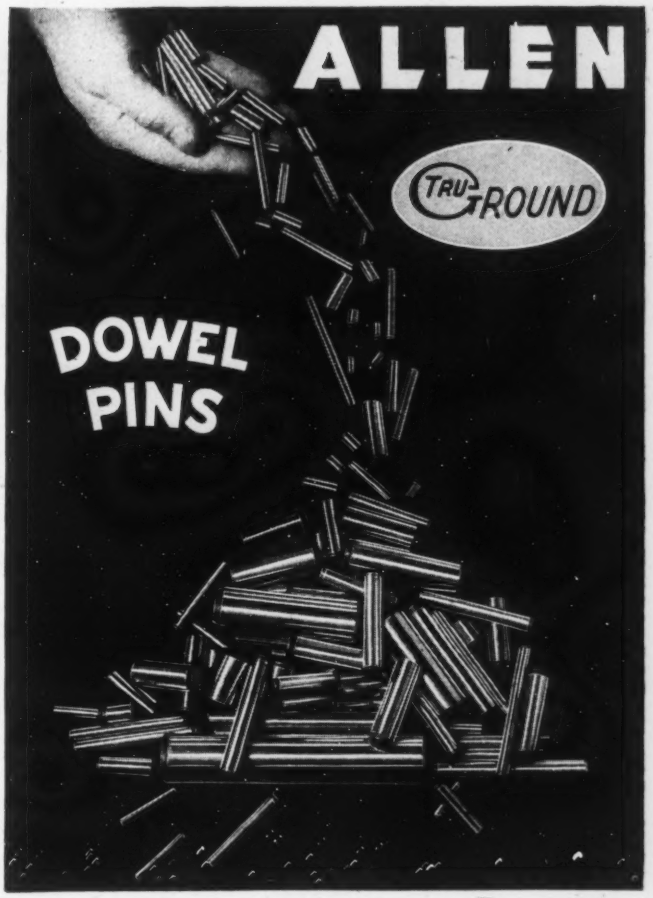

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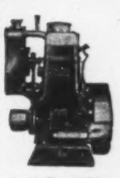

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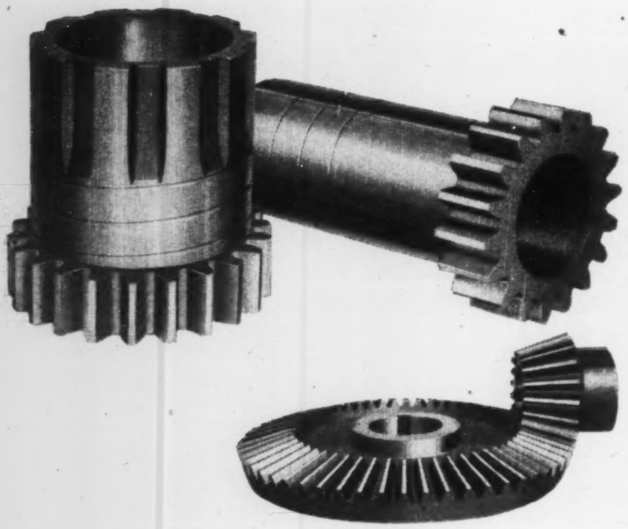

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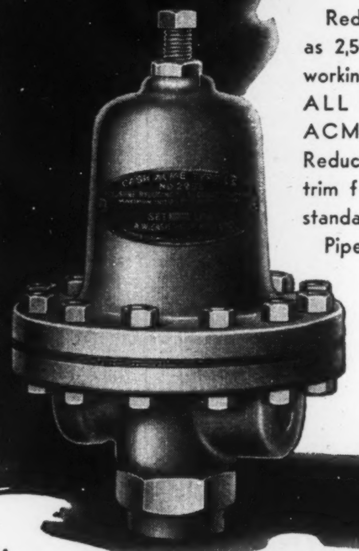

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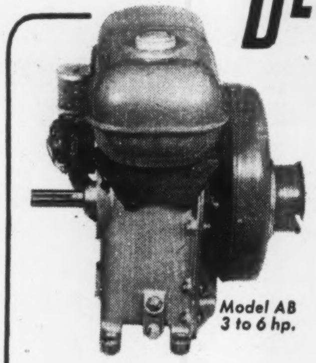
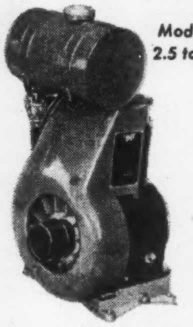


Model AB
3 to 6 hp.



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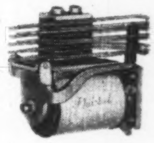
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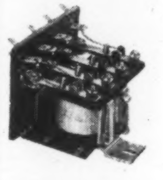
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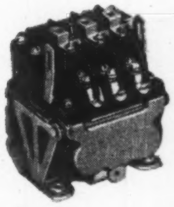
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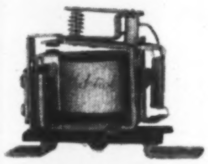
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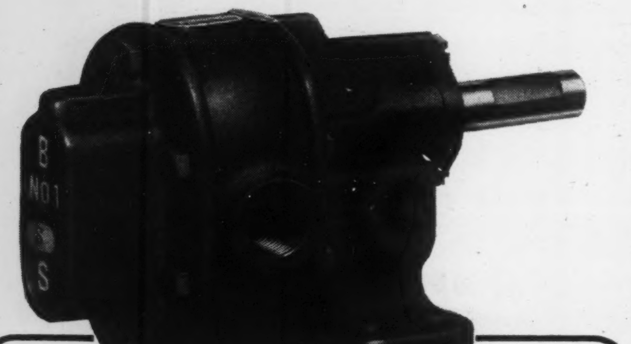

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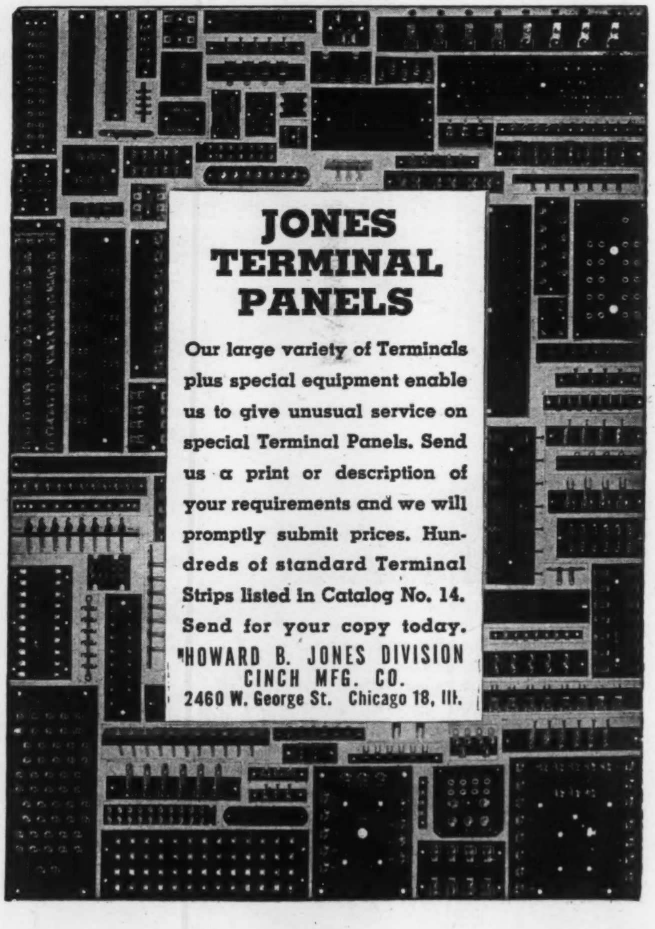

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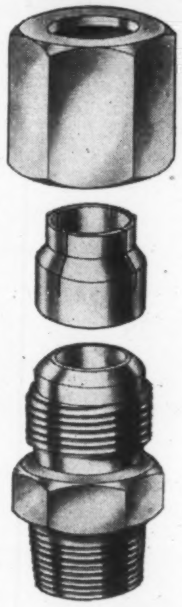

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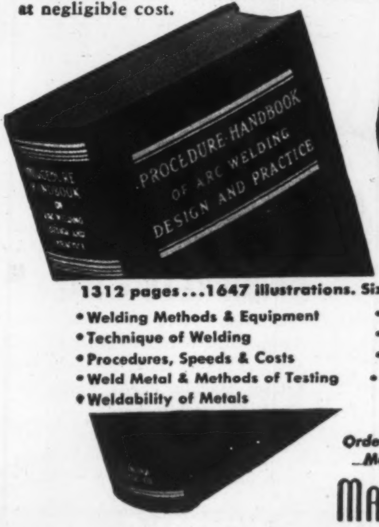

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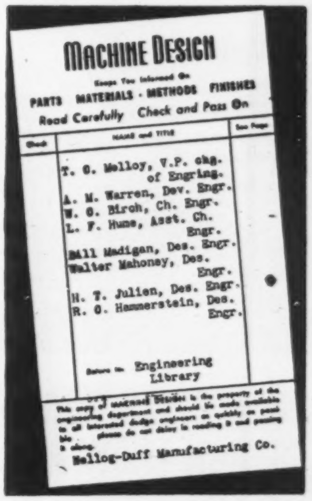

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AMERICAN CHAIN & CABLE

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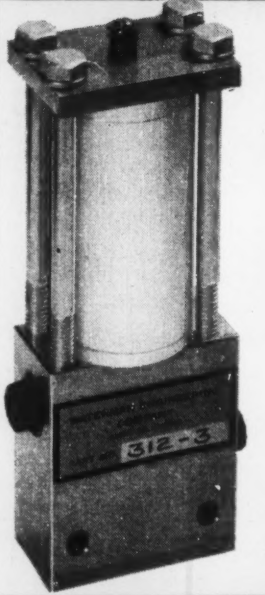

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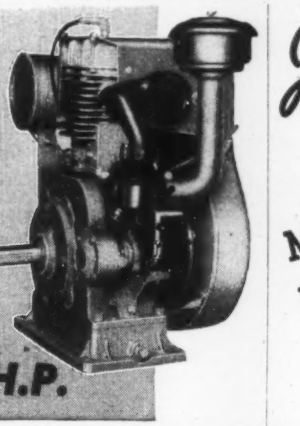

Illustrated above is the Models AEH to AHH series of 4-cycle single cylinder Wisconsin Air-Cooled Standard Engines, to which the following specifications apply:

MODEL	AEH	AFH	AGH	AHH
Bore	3"	3¼"	3½"	3⅝"
Stroke	3¼"	4"	4"	4"
Cu. in. Displ.	23	33.2	38.5	41.3
Hp. Range	4-6	5-7	6-8.5	7-9
Weight	130 lbs.	180 lbs.	180 lbs.	180 lbs.

If your equipment calls for an engine within the above power range, it will pay you to give serious consideration to the Wisconsin line . . . noted for rugged, heavy-duty serviceability and thorough-going dependability.

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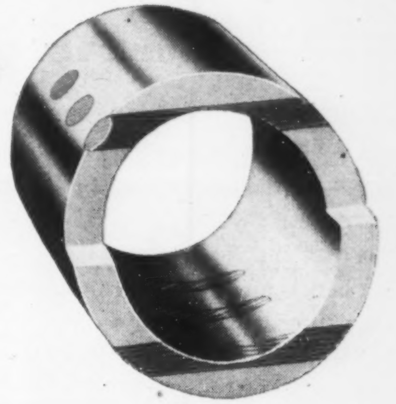

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"NEW IDEA" TO HIS NEPHEW

BUY BONDS HERE
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HAVE YOU told all your new or recently hired employees about the benefits of the Payroll Savings Plan for the regular purchase of U. S. Savings Bonds? Wage earners, according to a recent nation-wide survey, want security more than anything else. They prefer security to big pay, soft jobs, authority, "success."

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Your active support of the Payroll Savings Plan is an investment in employee contentment, in the citizenship of your community, and in the security of America's future. This is practical "employee relations" of the highest type and pays dividends of satisfaction to everyone.

Start a drive today for larger participation in the plan. Many employees may be unfamiliar with its advantages. If you want literature for distribution, contact your State Director of the Treasury Department's Savings Bonds Division.

New Savings Bonds Plan won't affect the P. S. P.

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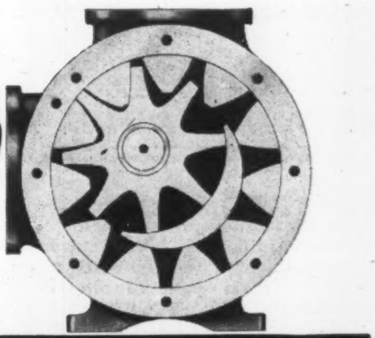
The Treasury Department acknowledges with appreciation the publication of this message by

MACHINE DESIGN

This is an official U. S. Treasury advertisement prepared under the auspices of the Treasury Department and The Advertising Council.

Here's a Worker!



VIKING ROTARY PUMPS

The pump that does the job well, day in and day out, is the one that's a worker. The Viking, with its "Gear Within a Gear—2 moving parts" principle, gives this type of service. Its rugged construction, without small intricate parts, springs, gadgets, etc., gives it the long, dependable life expected of a good pump.

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See Our Catalog In SWEETS

Viking PUMP COMPANY
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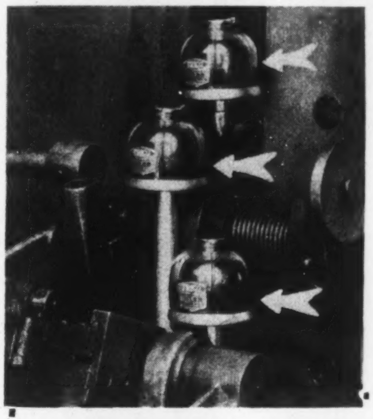

against

COSTLY HUMAN ERROR

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Stop wasteful, "trust-to-luck" hand oiling and assure your customers of . . .

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TRICO

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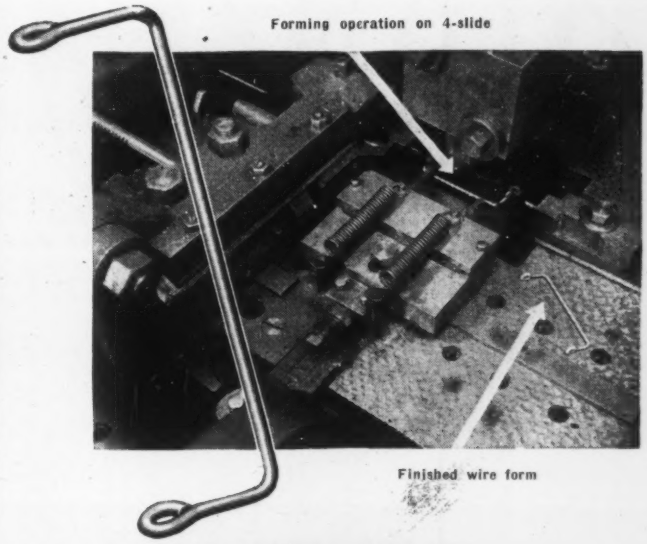

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is well equipped to make your **WIRE FORMS**

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When sending inquiry, describe springs or wire forms completely, sending sketch, samples, or blue print. Mention special requirements such as working space, initial tension, and load. Catalog on request.

THE RELIABLE SPRING & WIRE FORMS CO.
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ROUND AND FLAT WIRE SPRINGS · CLIPS HOOKS BENDS LIGHT STAMPINGS

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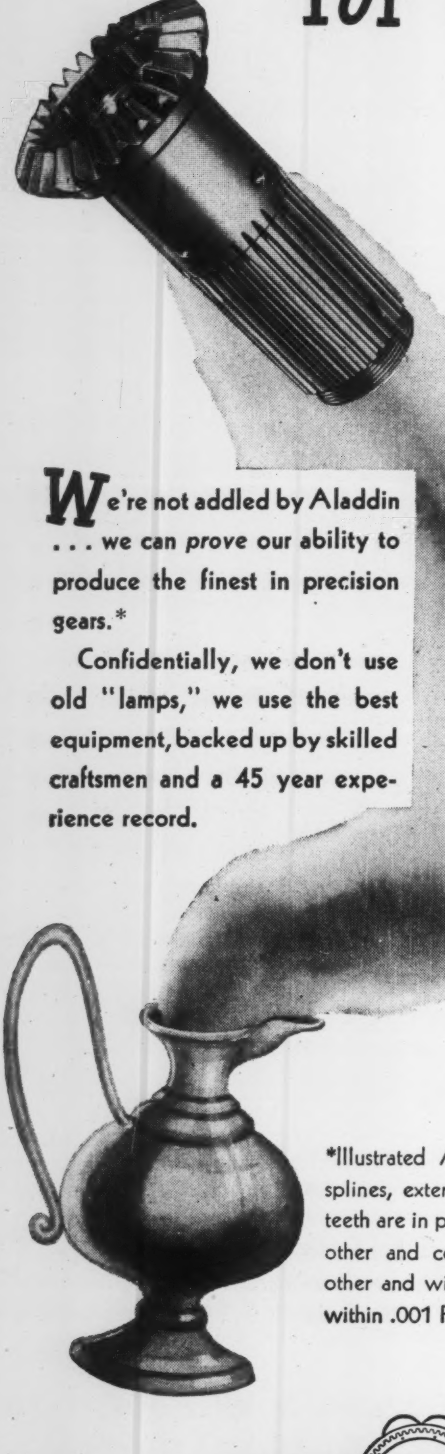

We're not addled by Aladdin . . . we can *prove* our ability to produce the finest in precision gears.*

Confidentially, we don't use old "lamps," we use the best equipment, backed up by skilled craftsmen and a 45 year experience record.

*Illustrated Above: The internal splines, external splines and gear teeth are in perfect time with each other and concentric with each other and with bearing diameters within .001 F.I.R.

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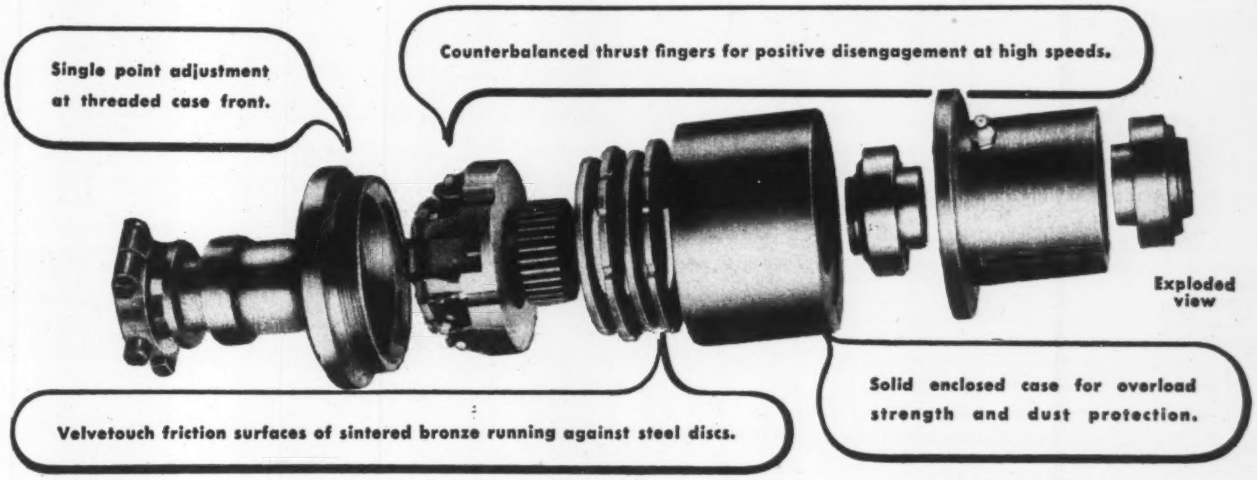

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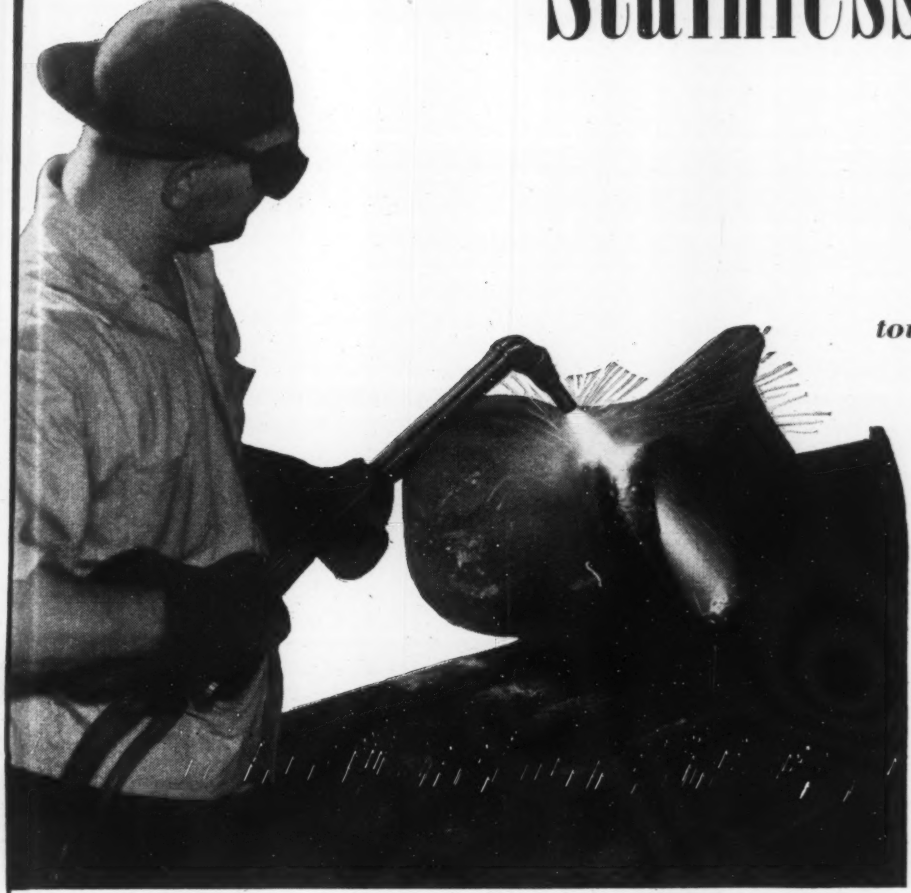

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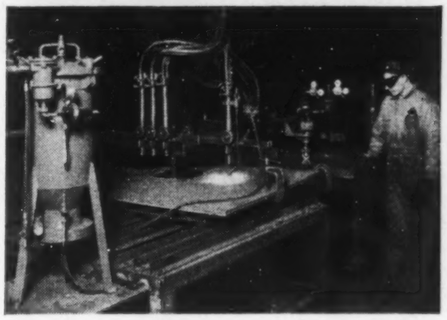

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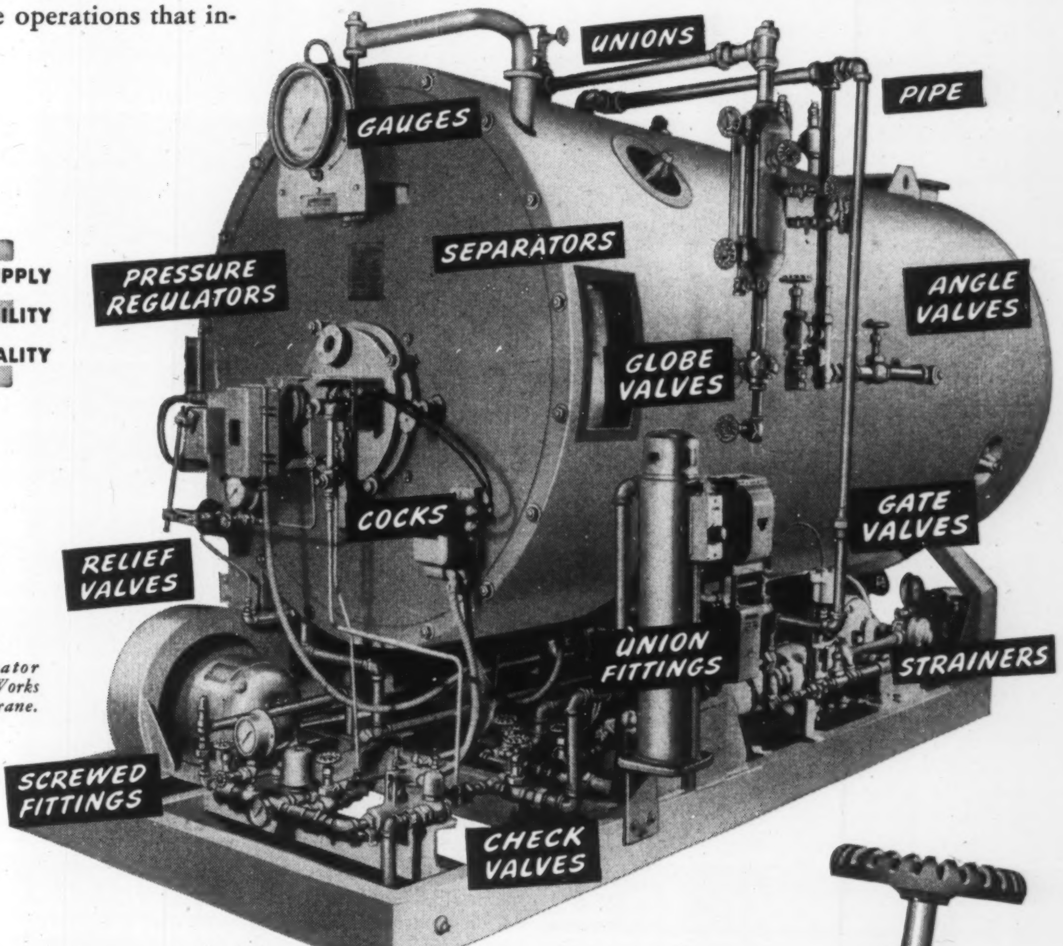
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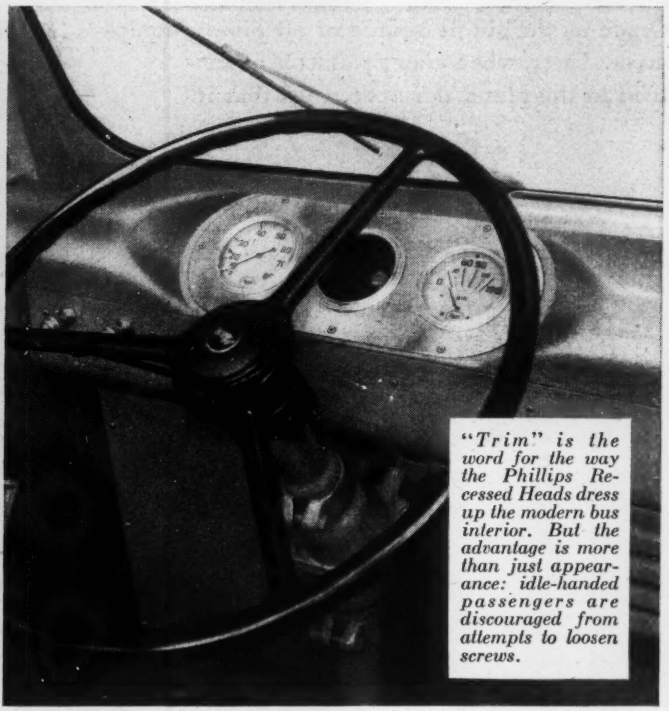

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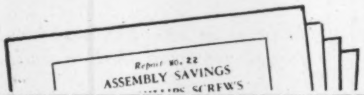

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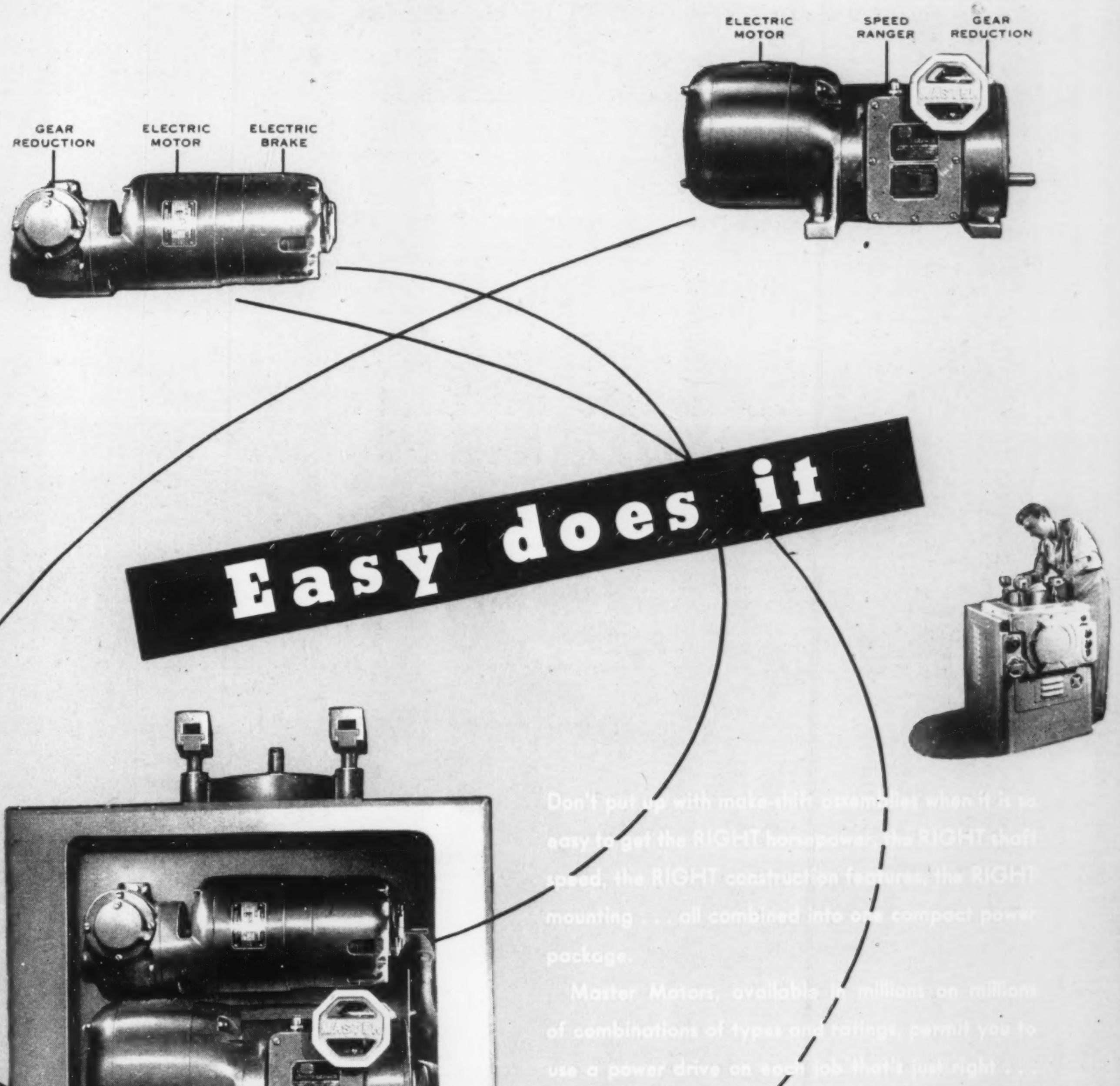
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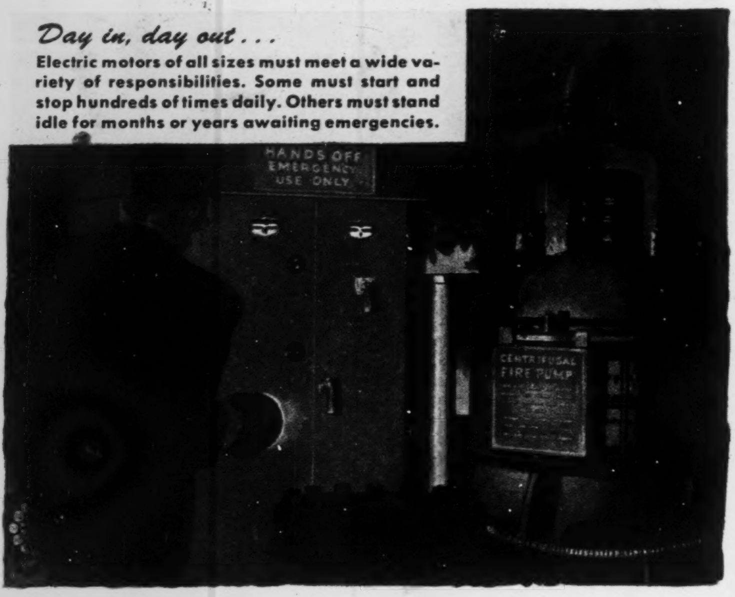

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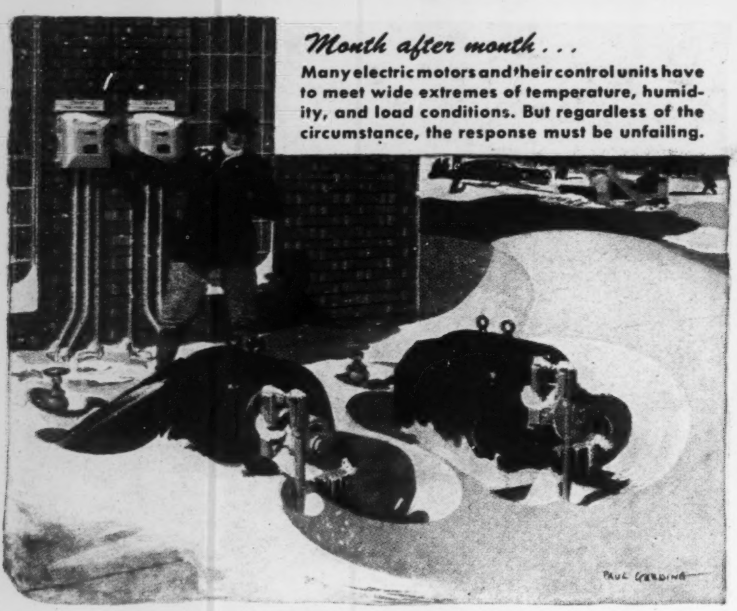

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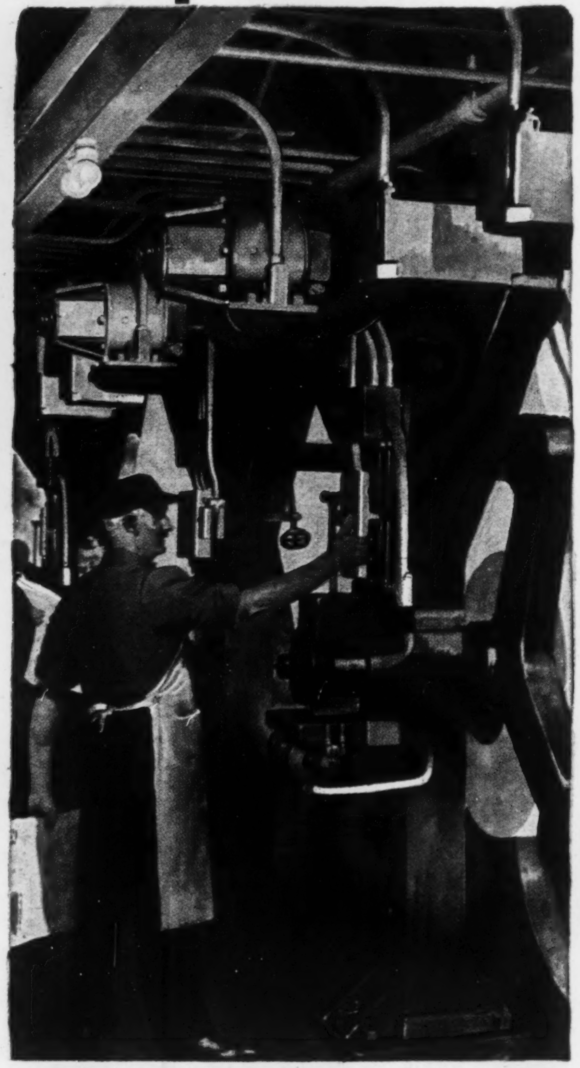

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